FURTHER STUDIES ON CORTICOLOUS MYXOMYCETES FROM WITHIN THE CITY LIMITS OF ATLANTA, GEORGIA

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ABSTRACT

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During a two-year period, beginning in the summer of 1973 and ending in the summer of 1975, a study was conducted on myxomycete bionta from bark of living trees growing in five widely separated localities within the Atlanta city limits. The objectives of the study were to determine (1) whether bark of living trees is a natural substratum for certain kinds of myxomycetes; (2) whether certain myxomycetes manifest affinities for certain species of trees; (3) whether seasonal variations exist in corticolous myxomycete occurrence; and (4) whether any correlation exists between the distribution of corticolous myxomycetes and tree habitats.

Since two earlier studies of limited scope represent the only reports of systematic studies on corticolous myxomycetes of Georgia, a need has existed for more extensive information on this myxomycete bionta of the state. This study was undertaken in order to fulfill

that need. To accomplish the objectives a total of 171 trees, representing 12 genera and 21 species, growing in five selected areas within the city limits of Atlanta, were chosen for the study. The genus and species of the trees used were *Acer negundo* and *A. saccharinum*, *Carya illinoensis* and *C. ovata*, *Cedrus deodara*, *Cornus florida*, *Diospyros virginiana*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Ostrya virginiana*, *Pinus echinata* and *P. taeda*, *Prunus serotina*, *Quercus alba*, *Q. falcata*, *Q. nigra*, *Q. phellos*, *Q. stellata*, and *Q. velutina*, *Ulmus alata* and *U. americana*.

The five different localities used in this study included three relatively undisturbed wooded areas and two open park areas. The localities were (1) a wooded area in the Highpoint section; (2) a wooded hillside in the Collier Heights section; (3) a wooded ravine in the Beecher Circle section; and (4) two city parks, namely, Washington and Piedmont Parks. Specific plots were selected within each locality for sampling. Each plot was approximately 15 meters square and contained at least one tree of each species that was to be studied. In two of the localities, viz., Collier Heights and Beecher Circle, fallen debris on the forest floor was periodically examined in the field.

Five different techniques were used to create conditions favorable for myxomycete development. These techniques were as follows: (1) a modification of the moist chamber technique originally used by Gilbert and Martin; (This modification involved the gradual soaking of bark pieces in sterile petri dishes by adding small volumes of sterile water intermittently as it was absorbed by the bark. This practice reduced the possibility of spores being discarded, as may happen when the method of Gilbert and Martin is used.) (2) the placing of bark samples in polyethylene bags and attaching these bags to the sides of the trees from which they were collected; (Sterile distilled water was added to the bags in order to first saturate the bark pieces and subsequently maintain a high humidity.) (3) the removal of bark samples from trees and the incubation of these samples in petri dish moist chambers that were left in the field at the base of the tree from which the samples were removed; (4) the attaching of large water-filled polyethylene bags to trees at about breast height; (The bags were perforated at the bottom by puncturing the corners and the middle with a few pin holes. This enabled water to slowly drip onto the bark below the bag and consequently keep the trunk in that region continuously moist.) and (5) the periodic examination of undisturbed bark of standing trees with a 10X hand lens in a search for naturally developing slime molds.

Field examinations of leaf litter were also made in order to determine whether myxomycetes that developed in moist chamber on bark samples also developed naturally on plant debris on the forest floor.

A total of 46 species of myxomycetes was found during the two years of the study. Forty species of myxomycetes, representing 16 genera, appeared on collected bark samples during the course of the study, and six other species representing six genera were found on field observed leaf litter. The following species of myxomycetes were found: Arcyria carnea, A. cinerea and A. nutans, Badhamia nitens and B. obovata, Calomyxa metallica, Ceratiomyxa fruticulosa, *Clastoderma debaryanum*, *Comatricha elegans*, *C. fimbriata*, *C. lurida*, *C. nigra* and *C. pulchella*, *Cribraria minutissima* and *C. violacea*, *Dictydium cancellatum*, *Diderma hemisphaericum*, *Didymium difforme*, *D. iridis* and *D. squamulosum*, *Echinostelium minutum*, *Enerthenema papillatum*, *Fuligo septica*, *Hemitrichia stipitata*, *Lamproderma scintillans*, *Licea erecta*, *L. kleistobolus* and *L. operculata*, *Lycogala epidendrum*, *Macbrideola cornea*, *M. decapillata*, *M. martinii*, *M. scintillans* and *M. synsporos*, *Metatrichia vesparium*, *Perichaena chrysosperma* and *P. minor*, *Physarum cinereum*, *P. crateriforme*, *P. decipiens*, *P. leucophaeum*, *P. nutans* and *P. viride*, *Stemonitis axifera*, *S. flavogenita*, *S. fusca* and *S. virginiensis*.

The data from this study show that some myxomycete species will develop only on bark of living trees, some species develop only on forest floor debris, and some species will develop on bark of living trees as well as on fallen debris. The species that appeared on fallen debris as well as on tree bark were *Arcyria cinerea* and *A. nutans*, *Physarum cinereum*, *P. nutans* and *P. viride*, *Stemonitis axifera* and *S. fusca*.

The species that were found on bark from living trees but were not found on fallen debris were *Badhamia obovata*, *Clastoderma debaryanum*, *Comatricha fimbriata*, *C. elegans*, and *C. nigra*, *Cribraria minutissima*, *C. violacea*, *Didymium squamulosum*, *Licea erecta*, *L. kleistobolus* and *L. operculata*, *Macbrideola synsporos*, *Perichaena chrysosperma* and *P. minor*, *Physarum crateriforme*, *P. decipiens*, and *P. leucophaeum*. The species of slime molds that were found on forest floor litter but were not found on bark of living trees were *Ceratiomyxa fruticulosa*, *Dictydium cancellatum*, *Fuligo septica*, *Hemitrichia* stipitata, Lycogala epidendrum, and Metatrichia vesparium. Echinostelium minutum is a ubiquitous species for it was common on bark from living trees as well as on fallen plant debris.

Throughout this study variations were noted in the number of species of slime molds appearing on incubated bark samples during different seasons of the year. Echinostelium minutum appeared throughout the year on bark of all trees sampled except Acer negundo, A. saccharinum, Cedrus deodara, and Quercus phellos. Didymium squamulosum was found throughout the entire collecting period, except for the spring of 1974. Except for the summer of 1973, Comatricha fimbriata appeared on bark samples collected each season over the two-year period of study. In some instances a slime mold may have appeared during a particular season in one year and may not have been found the following year during the same season. For example, Arcyria nutans was found during the winter of 1974, but was not found during the winter of 1973. Comatricha lurida appeared during the spring of 1974. Comatricha pulchella appeared only during the winter of 1974 as did Didymium difforme. Some slime mold species appeared only once during the course of the study. Macbrideola cornea and M. decapillata, Physarum cinereum, and Stemonitis axifera, are examples of species that were found once.

Based on the data from this study, bark of living trees appear to represent a natural substratum for some species of myxomycetes. Some general affinity is apparent between some species of trees and some species of myxomycetes, depending upon the locality. Also, the appearance of some species of corticolous myxomycetes may vary with the season of the year, and some correlation appears to exist between the distribution of some myxomycete species and tree habitat. Some of the myxomycetes found in this study represent species previously unreported from the state. Those species are *Calomyxa metallica*, *Clastoderma debaryanum*, *Badhamia nitens*, *B. obovata*, *Licea erecta*, *Macbrideola cornea*, *M. decapillata*, *M. martinii* and *M. synsporos*, *Perichaena minor*, *Physarum crateriforme*, *P. decipiens* and *P. leucophaeum*.

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CHAPTER I

INTRODUCTION

Ku (1969) was the first to conduct a systematic study on the occurrence of myxomycetes on bark of living trees in the Atlanta area as well as in the state of Georgia. Until that time little attention had been given to the myxomycete bionta of Georgia. Studies by Ku (1969), and Pendergrass (1972), are the only two reports of systematic studies on corticolous or non-corticolous Georgia myxomycetes. The only other references to species of myxomycetes occurring in Georgia are those made by various investigators who were on collecting trips to or through the state. These reports are found mainly in general taxonomic treatments of myxomycetes of North America, such as those authored by Hagelstein (1944), Macbride and Martin (1934), Martin (1949), and Martin and Alexopoulos (1969).

Since the earlier studies done by Ku and the author on corticolous myxomycetes covered, in each instance, a single year of investigation, with no field oriented studies, and were limited to a few species of trees, a need has existed for a more extensive study of the corticolous myxomycetes of Georgia. Such an investigation should involve a larger number of tree species, a greater variety of habitats, field observations, and a longer collection period. Data from an investigation of this nature should provide more definitive information on the question concerning bark of living trees as a natural substratum for myxomycete occurrence. This study was undertaken in order to fulfill that need.

The objectives of this study were to determine (1) whether bark of living trees is a natural substratum for certain kinds of myxomycetes; (2) whether certain myxomycetes manifest specificities for certain species of trees; (3) whether seasonal variations exists in corticolous myxomycete occurrence; and (4) whether any correlation exists between the distribution of corticolous myxomycetes and general environmental habitat.

It is anticipated that information from the study planned should shed further light on the question as to whether bark of living trees is a natural substrate for certain kinds of myxomycetes and should enhance our knowledge on the diversity of myxomycetes occurring in the state of Georgia. Data from this study should also aid in ascertaining whether or not corticolous myxomycete distribution is substantially affected by urban air pollutants.

CHAPTER II

REVIEW OF LITERATURE

H. C. Gilbert and G. W. Martin (1933) were the first to report the occurrence of corticolous myxomycetes. Their interest in studying myxomycetes from this type of substratum was the result of some unexpected observations. They reported that in April, 1932 a few pieces of bark, bearing an abundant growth of the alga *Protococcus*, were collected from the north side of a large cottonwood tree and placed in a moist chamber in the laboratory in an attempt to encourage alga development. Observations made a few days later revealed that, in addition to *Protococcus*, scattered sporangia of a small species of *Comatricha* was also present. Subsequent study revealed it to be *Comatricha fimbriata* Lister & Cran., a species previously known only from Great Britain. To obtain additional information on the occurrence of corticolous myxomycetes Gilbert and Martin made further examinations of similar bark cultures. These cultures revealed the presence of a substantial variety of myxomycetes. At first, they regarded these forms as unusual. However, after further studies, they suggested that corticolous myxomycetes were not really unusual but possibly widespread and common. Gilbert and Martin concluded that myxomycetes could be obtained readily if bark pieces were incubated in moist chambers.

In the study made by Gilbert and Martin (1933), bark collections were taken simultaneously from the north and south sides of the same trees at the same height. The results obtained from their study suggested that bark collected from the north side of the trees sampled generally produced a greater number and diversity of myxomycetes than bark from the south side of the trees. Bark pieces from the south side of the trees were productive, however, and yielded a variety of myxomycete forms. Gilbert and Martin did not speculate on probable reasons for the difference in myxomycete productivity noted between the north and south facing surfaces of the tree trunks observed.

Single species of the genera *Clastoderma*, *Echinostelium*, *Hymenobolina*, *Hemitrichia*, *Kleistobolus*, *Margarita*, *Oligonema*, *Ophiotheca*, *Orcadella*, *Perichaena*, and *Stemonitis* were reported in Gilbert and Martin's (1933) study, as well as two species of *Badhamia*, *Comatricha*, and *Licea*. Some of the species found appeared to be strictly corticolous. Other species were noted on substrata other than living tree bark.

Carr's study of myxomycete occurrence in a sandstone and a limestone region in Augusta County, Virginia, appears to be the first strictly ecological study of myxomycetes (Carr, 1939). The sandstone region was located near the base of the Blue Ridge Mountain, and the limestone area was located far into the Shenandoah Valley. Carr reported that the kinds of genera that he found in the limestone region generally differed from those found in the sandstone region. Certain species were abundant in limestone regions while in other regions they were either lacking or sparse in distribution over widespread areas. Ninety percent of the species collected that are typically devoid of lime were found in sandstone areas and only 10 percent of these species were found in the limestone region. The genera reported by Carr from limestone regions were *Physarum*, *Badhamia*, *Fuligo*, *Craterium*, *Leocarpus*, *Diderma*, *Diachea*, *Didymium*, and *Mucilago*. The genera reported from the sandstone region were *Didymium*, *Lamproderma*, *Comatricha*, *Arcyria*, *Stemonitis*, *Trichia*, *Hemitrichia*, *Oligonema*, and *Leocarpus*. Carr did not use the moist chamber technique in his study. Instead, field collections were made generally from old logs and sphagnum moss in the sandstone region, and from leaves and other vegetable materials in the limestone region.

A study on corticolous myxomycetes similar to that originally reported by Gilbert and Martin (1933) was conducted by Peterson (1952). Peterson selected for his collecting sites trees from a variety of habitats in the East Lansing, Michigan area. Those areas included deep woods, residential areas, river banks, and open woods. He also made observations on a few samples that were collected from trees growing in the residential section of Chicago, and DeKalb, Illinois.

Forty-two species of myxomycetes were found by Peterson during the course of his study. Twelve of the species had not been previously reported from the state of Michigan. This group included 3 species of *Arcyria*, 2 species of *Comatricha*, 6 species of *Licea*, and one species of *Physarum*. Peterson found ten different kinds of myxomycetes that he could not identify. He speculated that these forms were probably undescribed species. It appears, however, that Peterson published no additional information on the identity of these specimens.

According to Peterson (1952), his study was designed to obtain information on the occurrence of myxomycetes on the bark of living trees with five objectives in mind. They were (1) to determine the frequency of occurrence of myxomycetes on bark of living trees; (2) to correlate myxomycete occurrence with vertical position and direction of exposure of bark on tree trunk; (3) to correlate species and frequency of occurrence of myxomycetes with habitat of trees; (4) to correlate frequency of occurrence of myxomycete species with species of trees; and (5) to correlate frequency of occurrence of myxomycete species with seasons of the year.

Peterson reported that on the basis of the data accumulated during his study, there appeared to be no correlation between myxomycete occurrence and vertical position or direction of exposure of bark on the trees that he examined. He took bark samples from height levels of 1, 3, and 7 feet above the base of the tree. The positions used were located on the south and north facing sides of each tree trunk. A total of six different positions was used. He found that there was no significant difference in the productivity of myxomycetes from bark samples at different height levels or from various sides of the trees examined.

Peterson's comparison between myxomycete occurrence and tree habitat revealed that a significant correlation appeared to exist. He found the highest percentage of myxomycete occurrence in habitats where ground moisture was higher and where there was the least disturbances by man or his devices. Lower percentages occurred in habitats such as metropolitan areas and other well disturbed areas, especially those areas where air pollution sources were high.

Peterson reported inconclusive results in his attempt to determine whether or not affinities exist between myxomycete species and tree species. He indicated that this was possibly because his sample size for each species of trees used was not large enough. However, he did report that bark from certain tree species was more consistent in myxomycete productivity than others. He speculated that this difference in productivity might have been due to the physical and chemical composition of the bark of a certain tree species more so than any particular myxomycete affinity for a certain tree. Another significant observation of Peterson was that a species of myxomycete occurring on bark of a certain tree species in one particular location may not occur on the bark of the same tree in another habitat.

Peterson did not find any correlation between myxomycete occurrence and the season of the year. Some species were found throughout the year with no particular season appearing to favor the occurrence of these species. He reported finding a difference of only 8.8% between the season of highest species productivity and the season of lowest productivity. Peterson did not report a probable correlation between species and specific seasons.

Peterson began this study on the assumption that the bark of a living tree is a natural substratum for myxomycete occurrence. He concluded, however, that bark of living trees does not represent a natural habitat for myxomycetes and suggested that their presence on this kind of substratum is basically due to spore dispersal.

Another study involving corticolous myxomycetes as well as myxomycetes from decaying matter was conducted by Evenson (1961). She conducted a preliminary study of the myxomycetes of southern Arizona. The study was restricted to myxomycetes observed in an area that is within a radius of 90 miles of Tucson, Arizona. Evenson collected from five different localities in an attempt to correlate vegetation type and myxomycete species. Included in these localities were ponderosa pine or forest areas, desert shrub areas, desert grassland, chaparral, and landscaped parts of the city of Tucson.

Evenson reported that samples of living and decaying plant material collected from a few of the species from the forest areas and the majority of the species from the other vegetation zones were cultivated in moist chambers. She collected or cultured in moist chambers 63 species of myxomycetes. The highest myxomycete productivity was obtained from the forest areas. Evenson reported finding 52 myxomycete species in these areas. The forest vegetation area had the heaviest annual rainfall of all the areas that she studied. Sixteen myxomycete species were found in the desert shrub area, 7 in the desert grassland, 6 in the chaparral and the landscaped city areas. Included in the 63 species of myxomycetes found by Evenson were one species of <u>Lycogala</u>, <u>Dictydium</u>, <u>Calomyxa</u>, <u>Echinostelium</u>, <u>Clastoderma</u>, <u>Fuligo</u>, <u>Craterium</u>, <u>Leocarpus</u>, <u>Mucilago</u>, <u>Lepidoderma</u> and <u>Ceratiomyxa</u>; two species of <u>Licea</u>, <u>Lamproderma</u>, and <u>Diderma</u>; four species of <u>Perichaena</u>, <u>Arcyria</u>, and <u>Hemitrichia</u>; five species of <u>Trichia</u>, <u>Stemonitis</u>, and <u>Didymium</u>; and eight species of <u>Comatricha</u> and <u>Physarum</u>.

Evenson reported that even though collection of desert materials yielded only a few species of myxomycetes in her study, myxomycetes are very common in moist chamber cultures of desert plant material. As a result, she suggested that most myxomycete species are cosmopolitan, and that moisture is one of the requirements determining diversity and localization of species. Evenson also indicated that spore dispersal is chiefly a factor of the wind, with lesser roles being played by insects and other agents.

Brooks (1967) has conducted the most comprehensive study of corticolous myxomycetes to date. He reported that during the period between 1938 and 1941, when he was working on the myxomycetes of Kansas (Brooks, 1941, 1942), he used the moist chamber technique for culturing myxomycetes. It was at this time that he developed an interest in collecting corticolous forms. According to Brooks, from conversations with Robert Hagelstein, who was of the opinion that myxomycetes cultured in moist chambers were less typical than those collected in the field, he developed an interest in trying to find out if this contention were true. In July, 1962, while on a collecting trip in southern Kentucky, Brooks found fruiting bodies of *Physarum crateriforme* growing on the trunk of a red cedar. Further examinations of other trees revealed that many within that area had one or more species of myxomycetes growing on their bark. Some trees were found to have abundant fructifications of several species of myxomycetes.

In his study Brooks (1967) reported observations on tree habitats and the species occurring in those habitats. He also described his collecting techniques and gave detailed taxonomic treatment of the myxomycete species that he found. Brooks did most of his collecting in scattered areas of the central United States. These included areas such as Cumberland County, Kentucky, Geary and Riley Counties in Kansas, Crawford and Washington Counties in Northwestern Arkansas, Maury County in west-central Tennessee, and Pickett County in north-central Tennessee.

Brooks (1967) concluded that when bark samples are taken from the tree and placed in moist chamber culture, these pieces of bark are no longer subject to environmental conditions that are characteristic of the natural arboreal habitat. He suggested that chances are quite likely that those myxomycete species occurring after a few days of incubation in a moist chamber are truly corticolous. However, since bark samples are generally kept in moist chambers for several weeks or months, conditions are favorable for spores of many of the terrestrial species to germinate and ultimately give rise to fruiting bodies. His point was that myxomycete species found growing under arboreal conditions provide more proof of a natural habitat than those found growing under moist chamber conditions. Under _in vivo_ conditions there is exposure to the natural environmental changes which occur. Under moist chamber culture, conditions remain relatively constant. It was also noted in this study that generally during periods of rainy seasons myxomycetes occurred more abundantly and wider varieties of fruiting bodies were observed on the bark of trees.

In his study, Brooks reported the occurrence of corticolous myxomycetes belonging to the genera _Licea_, _Macbrideola_, _Echinostelium_, and _Badhamia_. He did not find on living trees the genera _Ceratiomyxa_, _Listerella_, _Enteridium_, _Reticularia_, _Tubifera_, _Lycogala_, _Dictydium_, _Lindbladia_, _Arcyrodes_, _Calonema_, _Cornuvia_, _Oligonema_, _Amaurochaete_, _Lamproderma_, _Schnella_, _Barbyella_, _Diachea_, _Leptoderma_, _Paradiachea_, Cienkowskia, Craterium, Erionema, Fuligo, Leocarpus, Physarella, Lepidoderma, Meylania, Mucilago, and Physarina. He reported Dictydiaethalium and Minakatella as being the only myxomycetes of the aethaloid type occurring on bark of living trees. Common terrestrial types of myxomycetes, such as Arcyria, Hemitrichia, and Stemonitis, appeared infrequently on trees during the course of Brook's study. He also reported that some of the common terrestrial forms of myxomycetes were represented by one or two species even though others occurred occasionally. These included the genera Cribraria, Diderma, Didymium, Physarum, and Trichia.

According to Brooks, 63 of the species he collected and treated in his study were present because of their microplasmodial nature and he considered them to be corticolous. He reported 21 species as representing undescribed taxa and probably new species. Eight species were reported for the first time from North America, viz., Badhamia armilata, Badhamiopsis ainoi, Echinostelium elachiston, E. fragile, Licea marginata, L. testudinacea, Macbrideola martinii, and Minakatella longifilia.

Brooks revised the taxonomic scheme as well as the evaluation of the taxonomic characteristics used previously by Martin (1949, 1960). This was done because difficulties were encountered when he tried to place several of the species found into genera and families as previously defined. Brooks concluded that the taxa were based on characteristics that were not clearly differentiated and indicated that these features failed to show adequately the relationship within the myxomycetes. For example, he proposed as new generic taxa

Badhamiopsis, Colligatispora, Crania, Meylania, and Physonema. He removed from the Stemonitales the genera Clastoderma, Barbyella, Elaeomyxa, Diachea, and Paradiachea. Brooks removed these genera from the Stemonitales because they were characterized by the exogenous origin of the hypothallus and stalk. Genera with these characteristics were placed in the Clastodermataceae, a new family proposed by Brooks. He considered this family to be a member of the Physarales. The genera Leptoderma, Colloderma, and Diacheopsis were also added to this family because of the similarity of capillitial characteristics.

The next study of appreciable significance involving corticolous myxomycetes appears to have been that conducted by Ku (1969). The results from Ku's thesis have not been published as of yet. Ku had two main objectives in his study, viz., (1) to determine the kinds of myxomycetes that occur on the bark of a selected group of trees growing in the Atlanta vicinity; and (2) to determine whether any correlation exists between the distribution of myxomycete species and tree species, urban and suburban environments, seasons of the year, and vertical distribution on tree trunks. Ku studied the occurrence of myxomycetes on bark of trees growing in restricted urban and suburban localities of metropolitan Atlanta. One collecting site was on the Atlanta University campus and the other site was located in a wooded area which at that time was just outside the city limits of urban Atlanta. This study by Ku appears to be the first systematic study of the myxomycete bionta in the state of Georgia.

Initially, Ku selected nine species of trees for his study.

They were Cornus florida, Fagus grandifolia, Ginkgo biloba, Liquidambar styraciflua, Pinus taeda, Quercus alba, Salix babylonica, Ulmus alata and Ulmus americana. Later he reduced the number of trees to be sampled to four. They were Pinus taeda, Quercus alba, Salix babylonica, and Ulmus alata. Bark from two of the initial nine tree species selected for study by Ku, viz., Ginkgo biloba and Fagus grandifolia, were found to be unproductive. Consequently, sample collections from trees representing these species were discontinued. He attributed the unproductivity of these trees to their bark characteristics. These trees have bark with a relatively thin, smooth surface and firm texture. Cornus florida, another one of the initial trees selected by Ku, and Liquidambar styraciflua, provided bark samples that were easily removed. They were not used throughout the study, however, because representatives of these species were not located at both collecting sites. For the principal part of his study, Ku's sample size, in terms of the number of trees bark samples were collected from, was relatively small. He sampled two trees for each tree species at the two collecting sites used.

Ku reported a total of twenty-five species of myxomycetes from bark samples that he collected. Included in this group was one species each of Cribraria, Didymium, Echinostelium, Lamproderma, Stemonitis, and Macbrideola; 2 species of Arcyria, and Licea; and 5 species of Comatricha, Perichaena, and Physarum.

In analyzing the results of his study, Ku attempted to determine whether any correlation existed in myxomycete occurrence and vertical distribution on tree trunks. His findings were in agreement with those of Peterson (1952), who found that the frequency of occurrence of myxomycete species did not vary with vertical height. Ku reported that species found at the base of the tree trunk were also frequently found at higher levels on the tree.

Data from Ku's study indicated that bark collected from trees growing in suburban areas were generally more productive in myxomycete yield than bark from trees growing in urban localities. Ku reported the presence of 15 species of myxomycetes on bark from the trees in the urban area and 22 species of myxomycetes growing on bark of the trees in the suburban locality. However, bark from loblolly pine trees in the urban locality was markedly more productive of myxomycetes than from trees of this species growing in the suburban locality. This difference in productivity percentage was due principally to the frequent occurrence of one myxomycete species, *Comatricha fimbriata*, on pine tree bark in the urban locality.

Ku also noted a presumed relationship between the season of the year and myxomycete occurrence. He reported finding *Arcyria globosa*, *Perichaena corticalis*, and *Stemonitis virginiensis* only during the summer. *Physarum viride* and *P. oblatum* occurred only during the winter on collected bark samples. The other myxomycete species were found generally at various times throughout the year. The most ubiquitous species was *Echinostelium minutum*. It appeared on bark samples from all trees and was found throughout the year. *Comatricha fimbriata* was found only on bark samples from *Pinus taeda*. The other species of myxomycetes found by Ku were not as restricted in distribution and occurred on bark from two or more of the species of trees studied.

In 1972, this author conducted an investigation similar to the study of Ku (Pendergrass, 1972). The objectives of that study were (1) to survey the corticolous myxomycete bionta of a relatively undisturbed and relatively pollution free natural area; (2) to determine whether affinities exist between species of corticolous myxomycetes and species of trees on which they occur; and (3) to determine whether the occurrence of corticolous myxomycetes is seasonal in nature.

To accomplish these objectives 42 trees growing in Panola Mountain State Park, a natural preserved area located approximately 20 miles southeast of Atlanta, were selected for the study. The species of the trees selected were *Quercus falcata* and *Q. prinus*, *Pinus taeda* and *P. echinata*, *Carya glabra*, *Cornus florida*, and *Liriodendron tulipifera*. Seven collection sites were selected in the park with each site representing a different ecological setting in which one or more trees of each of the seven tree species grew within a few meters of each other. Bark samples were removed at six-week intervals from the trees selected for study at each collection site, and these samples were subsequently incubated in moisture chambers under laboratory conditions.

In this study 23 species of myxomycetes, representing 12 genera, appeared on bark collected from the trees in Panola Mountain State Park. The species were *Arcyria carnea*, *A. cinerea* and *A. pomiformis*, *Comatricha elegans*, *C. fimbriata*, *C. lurida*, *C. nigra* and *C. suksdorfii*, *Cribraria minutissima* and *C. violacea*, *Clastoderma debaryanum*, *Diderma rugosum*, *Echinostelium minutum*, *Lamproderma* scintillans, Licea operculata, Metatrichia vesparium, Perichaena chrysosperma, Trichia floriformis, Didymium squamulosum and D. megalosporum, Physarum notabile, P. nudum and P. viride. The appearance of some species appeared to be seasonal, and some species were found only on the bark of certain tree species. Echinostelium minutum was the most ubiquitous species, as was the case in Ku's (1969) investigation. This species appeared throughout the year on bark of all tree samples. Cribraria minutissima also appeared throughout the year but only on Pinus taeda. Comatricha fimbriata was common in the fall on bark of Quercus falcata. The results of that study suggested that some degree of affinity may exist between bark of some species of trees and species of myxomycetes, that the appearance of some species of corticolous myxomycetes may vary with the season of the year, and that bark of living trees apparently represents a natural substratum for myxomycete bionta. Some of the species that were found in that study represented new records for the state of Georgia.

The only other ecological study of myxomycetes appears to be that of Klinge (1974). She conducted a study of environmental factors that influence myxomycete occurrence in three diverse woodland habitats. Among those factors examined by Klinge were light intensity, moisture content, mineral element content, hydrogen-ion concentration of the substrates, temperature at the site of myxomycete occurrence, and position of myxomycete on substrates. She concluded that, based on the moisture content data obtained, myxomycetes in nature have strict moisture requirements. It appeared that myxomycetes occurred primarily on substrates with high moisture content. Klinge also found that warmth from light, and not the light itself, may possibly be a more important factor influencing the development of myxomycetes on natural substrata. Additionally, she suggested that the position of myxomycetes on the substrate appears to have some influence on myxomycete occurrence depending upon the availability of light exposure. In support of this postulation she found that 61% of all myxomycete fructifications developed on south and upward facing portions of substrates where sunlight duration and intensity was greatest. She concluded, therefore, that light plays an important role in natural myxomycete incidence. Based on the light intensity tests that she conducted during the course of her study, Klinge also concluded that the cooler the climate, the greater the light intensity necessary for myxomycete occurrence.

This investigator (Klinge, 1974) also reported that hydrogen-ion concentration appears to play a role in myxomycete occurrence for she found that 57% of the total myxomycetes found were on a substratum having a pH from 4.5 to 5.5. This pattern of distribution suggests that myxomycetes appear to have an affinity for a relatively acidic substratum.

As a result of Klinge's studies, several factors emerge as influential to myxomycete occurrence, viz., light, temperature, pH, and position on the substratum. Based on chemical analysis of the substratum used, she reported the occurrence of 15 elements in the wood of beech, elm, birch, oak, maple, spruce, sweet gum, and musclewood. These elements appear to have no influence on myxomycete productivity, however. The 15 elements tested for in the substrata used were potassium, magnesium, sodium, silicon, manganese, iron, copper, molybdenum, phosphorus, zinc, strontium, calcium, boron, barium and aluminum. She stated that myxomycetes were no more abundant on substrates with high mineral content than they were on substrates with low mineral content.

From the six factors influencing myxomycete occurrence studied by Klinge the following factors were considered to be the most important: (1) light intensity; (2) moisture and pH content of substrate; and (3) position of the myxomycetes on the substrate.

CHAPTER III

MATERIALS AND METHODS

Bark samples were collected over a 24-month period from the trunk of living trees growing in 5 different localities within the Atlanta city limits. The collections began in June, 1973 and terminated in June, 1975. In some localities forest floor litter was examined for the presence of myxomycetes.

Three relatively undisturbed wooded areas and two city parks represent the five localities used in this study. The localities were (1) a wooded area in the Highpoint section; (2) a wooded hillside in the Collier Heights section; (3) a wooded ravine in the Beecher Circle section; (4) Washington Park; and (5) Piedmont Park.

After deciding on the localities to be used specific plots were selected within each locality for sampling. Each plot was approximately 15 meters square and contained at least one tree of each species chosen for study. Trees selected for sampling in each plot were chosen at random. Leaf litter observations were made in only two of the localities studied, viz., the Collier Heights and Beecher Circle localities. In each plot the tree species selected for sampling were not necessarily the same as the species selected in the other plots. In several instances, however, the same tree species were studied. Where this latter situation prevailed the opportunity for a more critical study of probable myxomycete species-tree species affinity was afforded. The trees from which samples were taken varied in age and size. No attempt was made to select trees of uniform size.

Ages of trees were not determined. The principal criterion used in selecting a tree suitable for sampling was the degree of bark development. Only trees with relatively thick, well-developed bark was used.

Description of Collecting Localities

The Highpoint locality is a relatively undisturbed wooded area located about 4 miles south of downtown Atlanta along the east side of Interstate 75-85. The area is bounded on the northeast and south by apartment complexes and on the west by Interstate 75-85, a heavily traveled highway. The proximity of the interstate highway introduces a probable higher pollution factor in the distribution of corticolous myxomycetes in this locality. This locality is also a forested area with a hilly topography. Trees cover the west slope and a more level eastern area. A stream runs along the base of this slope. The area is a *Pinus*-mixed hardwood association of trees. *Carya*, *Liquidambar*, *Quercus*, and *Acer* are the genera of hardwoods that predominate. The understory is primarily herbaceous.

Six collecting sites were chosen in the Highpoint locality. Each site represented a different habitat. All of the trees sampled within each site were within a few meters of each other. Thirty-nine trees were sampled in this locality. The collecting sites chosen included a plot below the ridge of the slope (Fig. 1), a plot along the stream (Fig. 2), a plot in open woods several meters from the stream (Fig. 3), a plot above the ridge of the slope (Fig. 4), a plot along the fence about 160 meters from the interstate highway (Fig. 5), and a plot in the flat area extending eastward from the base of the slope (Fig. 6).

The Collier Heights locality is a relatively undisturbed wooded

Fig. 1. Collection site in the Highpoint locality showing a plot below the ridge of the slope.

Fig. 2. Collection site along the stream in the Highpoint locality.

Fig. 3. Collection site several meters away from the stream in open woods in the Highpoint locality.

Fig. 4. A plot above the ridge of the slope in the Highpoint locality.


3

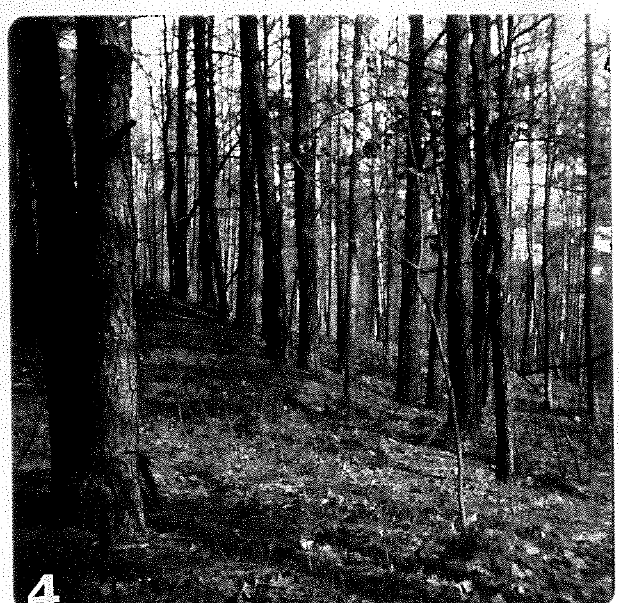
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Fig. 5. Collection site showing Interstate 75-85 about 25 meters away from the Highpoint locality.

Fig. 6. Collection site showing the flat area extending eastward from the base of the slope in the Highpoint locality.

area located about 7 miles west of downtown Atlanta. The locality is bounded on the north by Collier Road, a main thoroughfare. An elementary school and open field form the east boundary and the south and west sides are bounded by Interstates 20 and 285, respectively. With heavily traveled thoroughfares nearly surrounding the Collier Heights locality, some pollution influence from vehicular emission would be expected.

The forested area in the Collier Heights locality covers the north, east, and west sides of a hill. This hill is reported to be the highest point in Atlanta. The area is well-drained. Run off from rainfall is carried away by a ditch-like depression that runs through the center of the hillside in a north-south direction. Six sites were selected in this locality. One site was located on the southeast side of the area towards Interstate 20 (Fig. 7); a second was located on the south slope of a hill (Fig. 8); a third was located along the ditch-like depression (Fig. 9); a fourth was located about 984 meters into the forest in an old dumping area (Fig. 10); a fifth site was located in the open woods (Fig. 11); and the sixth site was located on the northeast slope of the hill approximately 2 meters away from Collier Road (Fig. 12). A *Quercus-Pinus-Carya* tree association predominates in the Collier Heights locality, with an *Oxydendron arboreum* understory. Thirty-four trees were used from this locality for study. This locality was also used for leaf litter observations since litter was abundant on the forest floor.

The third wooded locality used in this study was in the Beecher Circle community, an area located off Edgewater Drive in southwest

Fig. 7. View from the southeast side of the Collier Heights locality showing collection sites.

Fig. 8. Collecting site on the south slope of the hill at the Collier Heights locality.


7


8

Fig. 9. Collection site located along the ditch-like depression in the Collier Heights locality.

Fig. 10. Collecting site showing old dumping area located in the middle of the plot in the Collier Heights locality.


9


10

Fig. 11. Collection site located in the open woods of the Collier Heights locality.

Fig. 12. Collection site located on the northeast slope of the Collier Heights locality approximately 2 meters away from Collier Road.

Atlanta. This locality is approximately 6 miles southwest of downtown Atlanta. The Beecher Circle locality is characterized by forested slopes and a relatively deep ravine. The area remains relatively moist the entire year. A stream running through the center of the area in a north-south direction creates a relatively deep ravine. The locality is in the middle of a residential community. It is bounded on the south, east, and west by moderately traveled streets. The northern part of the locality extends as a forested area for a mile or more towards and beyond Utoy Creek.

A total of six sites was used in this area. The collecting sites chosen included a plot along and crossing the stream (Fig. 13), two sites along the east slope in the pathway of rainfall drainage leading to the stream (Figs. 14, 15), a plot in the open woods along the ridge of the ravine (Fig. 16), and two plots on the west side of Edgewater Drive about 2 meters away from the street (Figs. 17, 18). Thirty-five trees were selected for study. A mixed hardwood tree association with scattered pines predominates in the locality. The principal hardwood genera are Liriodendron, Liquidambar, and Quercus.

Washington Park provided one of the examples of a disturbed locality for this study. The park is located approximately 2-1/2 miles west of downtown Atlanta. It is in the middle of a residential area. A railroad line runs along the west side of the park. Surface streets or homes are located on the other sides.

Six sites were selected in Washington Park for collecting bark samples. Two of the plots were selected on the west side of the park, with one being in the northwest area (Fig. 19) and the other

Fig. 13. Collection site along and crossing the stream that runs through the center of the Beecher Circle locality.

Fig. 14. A site in the Beecher Circle locality along the east slope where a drainage pathway leads to the stream.


13


14

Fig. 15. A site in the Beecher Circle locality along the east slope where a drainage pathway leads to the stream.

Fig. 16. A plot in the open woods of the Beecher Circle locality in the open woods along the ridge of the ravine.


15


16

Fig. 17. Collection site on the northwest side of Edgewater Drive in the Beecher Circle locality about 2 meters away from the street.

Fig. 18. Collection site on the southwest side of Edgewater Drive in the Beecher Circle locality about 2 meters away from the street.


17

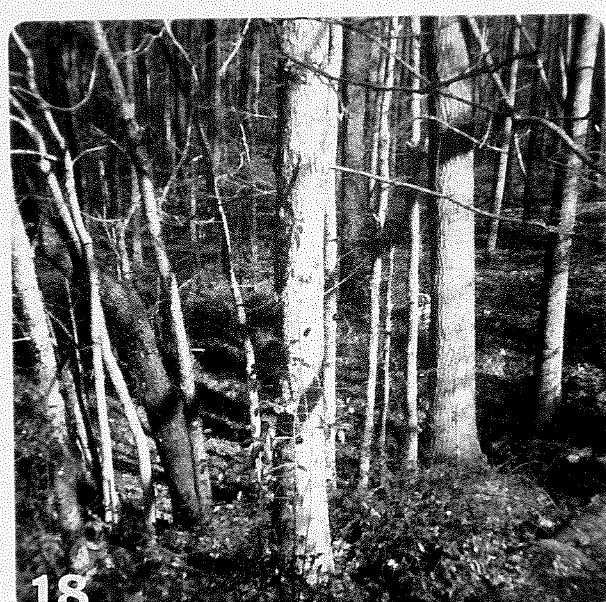
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Fig. 19. Collection site in the northwest section of Washington Park.

Fig. 20. Collection site in the southwest section of Washington Park.


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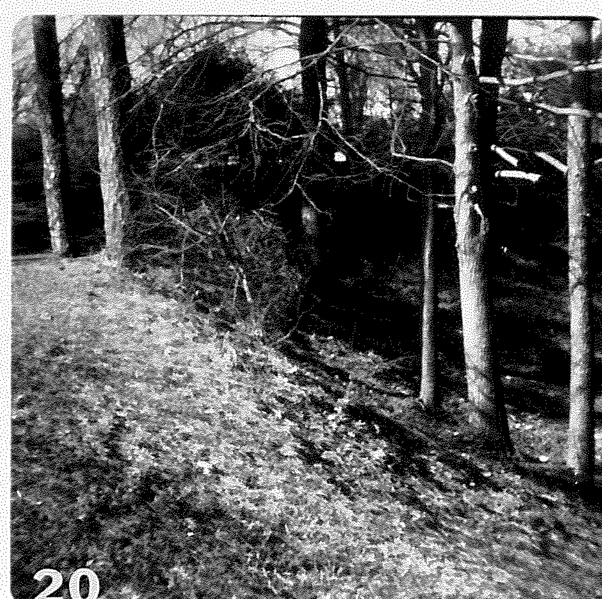
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in the southwest area (Fig. 20). Two plots were selected on the east side at the south and north ends of the park (Fig. 21, 22). The other two plots were located in the center of the park approximately 14 meters apart, with one site having an understory of herbaceous plants (Fig. 23) and the other with no understory (Fig. 24). Thirty-five trees, representing mainly Liriodendron-Carya, Pinus-Diospyros, and Quercus-Pinus, were the principal tree associations in the park. Cornus florida made up the understory in the open wooded area of the park.

The fifth locality used in this study was Piedmont Park, a park heavily used for sightseeing, sports events, concerts, and numerous other activities. There is heavy traffic in the park and it is bordered on all sides by heavily traveled thoroughfares. This park is located approximately 3 miles from downtown Atlanta in the northeast section of the city.

Twenty-eight trees were selected for study in Piedmont Park. Since trees were much more widely separated in this park, 6 plots were selected for collecting specimens. One plot was located along the golf course (Fig. 25), one along one of the roads running through the park (Fig. 26), one along the lake in the park (Fig. 27), one in the central area of the park near the concession stand (Fig. 28), one at the end of the park near the southwest entrance (Fig. 29), and one along Piedmont Road, a heavily traveled artery on the park's west side (Fig. 30). Species of Ulmus, Carya, Liriodendron, Quercus, Cornus, Pinus and Liquidambar are common in the park.

Trees (171 in number) representing 12 genera and 21 species

Fig. 21. Collection site on the east side and south end of Washington Park.

Fig. 22. Collection site on the east side and north end of Washington Park.


21

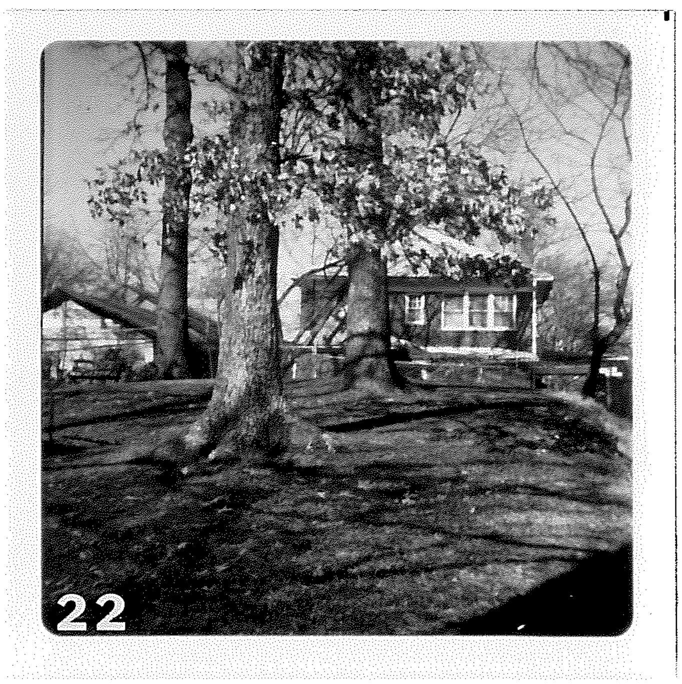
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Fig. 23. Collection site with understory in the center of Washington Park.

Fig. 24. Collection site without understory in the center of Washington Park.


23

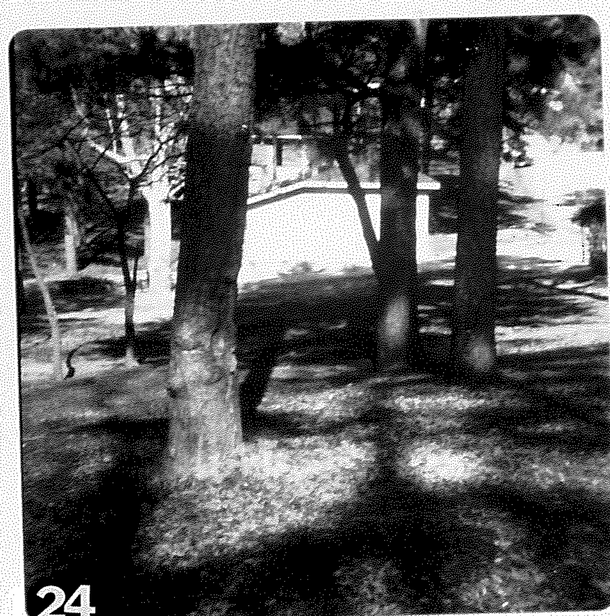
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Fig. 25. Collection site on the north end of the golf course in Piedmont Park.

Fig. 26. Collection site along streets running through Piedmont Park.

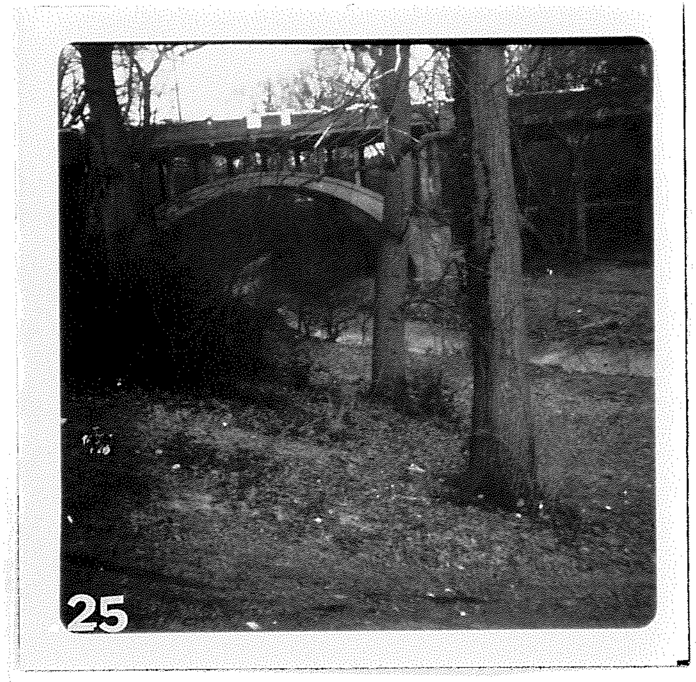
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Fig. 27. Collection site along the lake in Piedmont Park.

Fig. 28. Collection site in the center of Piedmont Park near concession stand.


27


28

Fig. 29. Collection site in Piedmont Park at the end of the park near the southwest entrance.

Fig. 30. Collection site along Piedmont Road on the park's west side.

were used in this study. They were as follows: Acer negundo and A. saccharinum, Carya illinoensis and C. ovata, Cornus florida, Cedrus deodara, Diospyros virginiana, Prunus serotina, Liquidambar styraciflua, Liriodendron tulipifera, Ostrya virginiana, Pinus echinata and P. taeda, Quercus alba, Q. falcata, Q. nigra, Q. phellos, Q. stellata and Q. velutina, Ulmus alata and U. americana.

Bark Culture Moist Chamber Technique

Bark samples were obtained from trees with loose-textured bark by removing small pieces, approximately 5 X 6 cm in size, from the tree trunks with a sharp knife. When bark pieces were fairly hard to remove, a long pointed screw-driver was used to chisel out suitable size samples. The samples were taken at random from each tree trunk in a zone extending from near the base of the tree to slightly above breast height. Occasionally bark pieces were taken from one-half to 1 meter above head height that is between a 2 or 3 meter level. Each recorded collection was represented by 4 pieces of bark. All leaf litter observations were made in the field.

Polyethylene bags were used for transporting bark pieces from the field after removing them from the tree. The data, collection site, and the tree sampled were recorded for each collection. In the laboratory bark samples were placed in sterile petri dishes. Because of the possibility of discarding spores when employing the method by Gilbert and Martin (1933), a modification of this technique was used in this study. The modification involved slowly soaking bark pieces after placing them in petri dishes by adding small volumes of sterile water intermittently as it was absorbed by the bark pieces. When the bark pieces appeared soaked enough to create a highly moist condition within the petri dishes, no more water was added. Samples were then set aside on shelves in the laboratory to allow myxomycetes to develop. They were maintained in a moderate moist condition for a period of up to 6 weeks before they were discarded. Regular microscopic examinations for myxomycete presence were made a day after incubation and continued periodically over a six-week period.

As fruiting bodies appeared on bark samples they were allowed to mature before the portion of the bark on which they were located was removed from the moisture chamber. Detached pieces of bark bearing mature fruiting bodies were taken out of the moisture chamber and, in some instances, slide mounts of fresh specimens were immediately prepared for study and identification. In other instances the specimens were allowed to air dry and were subsequently stored in small cardboard boxes for later examinations. Specimens were permanently mounted for herbarium deposit by using Elmer's glue to affix bark pieces to the bottom of small cardboard boxes.

Field Modifications of the Moist Chamber Method

A field modification of the moist chamber technique involved placing bark samples in polyethylene bags and attaching these bags to the sides of the trees from which they were collected (Fig. 31). Sterile distilled water was added to the bag in order to first saturate the bark pieces and subsequently maintain a high humidity. No specific water level was maintained in the bags; however, the bark pieces were not submerged. Additional water was added as needed over a period of four weeks in order to maintain a high humidity and allow time for myxomycetes to develop. When fruiting bodies appeared,

Fig. 31. Polyethylene bag containing bark samples attached to the side of a loblolly pine.

Fig. 32. Petri dish moist chamber in the field at the base of a loblolly pine tree.


31


32

that portion of the bark containing fruiting bodies was removed from the bag and placed in petri dishes for laboratory study and identification.

A modification of the technique described above involved removing bark samples from trees and placing them in petri dish moist chambers (Fig. 32) that were left in the field at the base of the trees from which the samples were removed. These bark cultures were examined periodically for the presence of myxomycetes. Water was added as needed in order to maintain a high humidity within the chamber.

Another field modification used in this study involved partially filling large polyethylene bags with water and attaching them to trees at about breast height (Fig. 33). The bags were perforated at the bottom by puncturing the corners and the middle with a few pin holes. This allowed water to drip slowly onto the bark surface below. Each morning and evening the bags were refilled with tap water. The bark surface below each bag was frequently examined for the presence of slime molds. When slime molds appeared the bark pieces on which they developed were removed and the specimens were taken to the laboratory.

The only other method followed for the *in vivo* study of corticolous myxomycete occurrence was to periodically examine directly bark of standing trees with a 10X hand lens. These examinations were made especially after rainy periods of several days duration. Myxomycete fruiting bodies discovered naturally developing on tree trunks were allowed to mature and were subsequently collected. Fruiting bodies developing under these conditions are shown in Figs. 34 and 35.

Fig. 33. Pin-hole punctured polyethylene bag, containing water, attached to the side of a loblolly pine tree.


33

Fig. 34. Myxomycete fruiting bodies *in situ* on tree trunk.


34

Fig. 35. Myxomycete fruiting bodies *in situ* on tree trunk.


35

In two of the localities, field and laboratory observations were made on leaf litter. Fruiting bodies discovered on leaf litter were carried to the laboratory for further observations and identification.

Polaroid type 47 film was used for black and white photographs. Kodak 135 Ektachrome X was used for color slides. Slide mounts of specimens were photographed with a Wild M-20 microscope equipped with a photo-automat. Whole mounts of some specimens and *in situ* photographs in the field were taken by Ray Simons of the Fernbank Science Center.

CHAPTER IV

OBSERVATIONS

Productivity of Bark from Trees Sampled

During the course of this study 171 trees were sampled. Each tree was sampled 14 times during the two years that the study was in progress. A total of 2,394 collections was made (Table 1). Each collection represented four bark pieces removed from the trunk of each tree.

Variations were first noted in the productivity of bark collections, in terms of myxomycete fruiting body yield. A collection was regarded as "productive" when one or more of the four samples removed from an individual tree yielded fruiting bodies. Occasionally, in several instances, plasmodia were observed on bark pieces but fruiting bodies failed to appear. Those samples yielding plasmodia only were counted as being "positive" for myxomycete occurrence but were not included in the productivity data. Myxomycete fruiting bodies developed in 1,712 of the collections. Plasmodia only appeared in 9 collections. Out of a total of 2,394 collections, 1,712 or 71.5%, were positive for myxomycete occurrence, and 682, or 28.5%, were negative. These data are presented in Table 1.

The data presented in Table 1 reveal that myxomycetes are common in occurrence and abundance on bark of living trees in the Atlanta area. As shown in the table, during the summer season 75.1% of the collections were positive, 72.5% in the spring, 70.6% in the winter, and 66.9% during the fall season. All the data in Table 1 represent

Table 1. Summary of collection data on myxomycete productivity of bark from living trees growing in selected areas within the city limits of Atlanta.

Seasons	Bark Collections No. positive	No. negative	Total no. of Collections	% Positive
Fall[1]	366[2]	181	547	66.9
Winter	434	181	615	70.6
Spring	372	141	513	72.5
Summer	540	179	719	75.1
Grand Total	1,712	682	2,394	71.5

[1] Represents two seasons for both years of the study.

[2] Each collection represents four bark samples.

two years of study and each season is represented twice. These figures indicate that tree bark from the twenty-one species of trees studied represents a highly favorable substratum for colonization by certain species of myxomycetes.

The data obtained have been analyzed to determine whether any apparent correlation between myxomycete species and tree species can be ascertained (Table 2). These data indicate that probable affinities exist between species of corticolous myxomycetes and the bark of some tree species. For example, *Macbrideola decapillata* occurred only on bark of *Quercus stellata* and *Macbrideola cornea* appeared only on bark of *Q. alba*. *Arcyria carnea* appeared only on bark of *Q. alba* whereas *Didymium iridis* was found only on bark of *Acer negundo*. Bark samples from other trees occurring in the same plots as those yielding the three slime mold species mentioned never produced either of the three species. The results from this study, and those of Ku (1969) and Pendergrass (1972) provide corroborating evidence in favor of the suggestions that a correlation exists between some species of corticolous myxomycetes and species of trees. Since this investigation extended over a period of two years and involved extensive sampling of each tree species, the results provide a firmer basis for correlating myxomycete species-tree species affinities. This observation will be discussed later in more detail.

Some species of slime molds were found on bark from each of the several tree species studied with the exception of *Quercus phellos*. This species of oak was non-productive throughout the study. This finding is surprising since slime molds appeared on bark samples from trees growing in the same plot with *Q. phellos*. Bark collections from trees adjacent

Table 2. Species of corticolous myxomycetes obtained from bark of 21 species of trees growing within the city limits of Atlanta.

Tree Species	Species of Myxomycetes from Bark Samples			
	Arcyria carnea	*A. cinerea*	*A. nutans*	*Badhamia nitens*
Acer negundo	–	–	–	–
A. saccharinum	–	–	–	–
Carya illinoensis	–	–	–	–
C. ovata	–	+	–	–
Cedrus deodara	–	–	–	–
Cornus florida	–	–	–	–
Diospyros virginiana	–	+	–	–
Liquidambar styraciflua	–	+	–	+
Liriodendron tulipifera	–	+	–	–
Ostrya virginiana	–	–	–	–
Pinus echinata	–	–	–	–
P. taeda	–	+	+	–
Prunus serotina	–	+	–	–
Quercus alba	+	+	–	–
Q. falcata	–	+	–	–
Q. nigra	–	–	–	–
Q. phellos	–	–	–	–
Q. stellata	–	+	–	–
Q. velutina	–	+	–	–
Ulmus alata	–	+	–	–
U. americana	–	–	–	–

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples *Badhamia obovata*	*Calomyxa metallica*	*Clastoderma debaryanum*
Acer negundo	-	-	+
A. saccharinum	-	-	+
Carya illinoensis	-	-	+
C. ovata	+	-	+
Cedrus deodara	-	-	-
Cornus florida	-	-	-
Diospyros virginiana	-	+	-
Liquidambar styraciflua	-	-	+
Liriodendron tulipifera	-	+	+
Ostyra virginiana	+	-	-
Pinus echinata	-	-	-
P. taeda	-	-	-
Prunus serotina	-	-	+
Quercus alba	+	-	+
Quercus falcata	-	+	+
Q. nigra	-	-	-
Q. phellos	-	-	-
Q. stellata	-	-	+
Q. velutina	-	-	+
Ulmus alata	-	-	-
U. americana	-	+	-

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples		
	Comatricha elegans	C. fimbriata	C. lurida
Acer negundo	-	+	-
A. saccharinum	-	-	-
Carya illinoensis	+	+	-
C. ovata	+	+	-
Cedrus deodara	+	+	-
Cornus florida	-	-	-
Diospyros virginiana	-	+	-
Liquidambar styraciflua	+	+	-
Liriodendron tulipifera	+	+	+
Ostrya virginiana	-	-	-
Pinus echinata	+	+	-
P. taeda	+	+	-
Prunus serotina	+	+	-
Quercus alba	+	+	-
Q. falcata	-	+	-
Q. nigra	+	-	-
Q. phellos	-	-	-
Q. stellata	+	+	-
Q. velutina	-	-	-
Ulmus alata	+	+	-
U. americana	-	+	-

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples: *Comatricha nigra*	*C. pulchella*	*Cribraria minutissima*
Acer negundo	–	–	–
A. saccharinum	–	–	–
Carya illinoensis	–	–	+
C. ovata	+	–	+
Cedrus deodara	–	–	+
Cornus florida	–	–	–
Diospyros virginiana	–	–	–
Liquidambar styraciflua	–	–	+
Liriodendron tulipifera	–	–	+
Ostrya virginiana	–	–	–
Pinus echinata	–	–	+
P. taeda	+	–	+
Prunus serotina	–	–	+
Quercus alba	–	+	+
Q. falcata	–	–	+
Q. nigra	–	–	–
Q. phellos	–	–	–
Q. stellata	–	–	+
Q. velutina	+	–	+
Ulmus alata	–	–	+
U. americana	–	–	–

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples *Cribraria violacea*	*Diderma hemisphaericum*	*Didymium difforme*
Acer negundo	-	-	-
A. saccharinum	-	+	-
Carya illinoensis	+	-	-
C. ovata	+	-	-
Cedrus deodara	-	-	-
Cornus florida	-	-	-
Diospyros virginiana	-	-	-
Liquidambar styraciflua	+	-	-
Liriodendron tulipifera	+	-	-
Ostrya virginiana	+	-	-
Pinus echinata	-	-	-
P. taeda	-	-	-
Prunus serotina	-	-	-
Quercus alba	+	-	-
Q. falcata	-	-	-
Q. nigra	-	-	-
Q. phellos	-	-	-
Q. stellata	+	-	+
Q. velutina	-	-	-
Ulmus alata	+	-	-
U. americana	+	-	-

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples Didymium iridis	D. squamulosum	Echinostelium minutum
Acer negundo	+	+	–
A. saccharinum	–	+	–
Carya illinoensis	–	+	+
C. ovata	–	+	+
Cedrus deodara	–	–	–
Cornus florida	–	+	+
Diospyros virginiana	–	+	+
Liquidambar styraciflua	–	+	+
Liriodendron tulipifera	–	+	+
Ostrya virginiana	–	–	+
Pinus echinata	–	–	+
P. taeda	–	+	+
Prunus serotina	–	–	+
Quercus alba	–	+	+
Q. falcata	–	+	+
Q. nigra	–	+	+
Q. phellos	–	–	–
Q. stellata	–	+	+
Q. velutina	–	–	+
Ulmus alata	–	–	+
U. americana	–	–	+

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples		
	Enerthenema papillatum	*Lamproderma scintillans*	*Licea erecta*
Acer negundo	-	-	-
A. saccharinum	-	-	+
Carya illinoensis	-	-	-
C. ovata	-	-	+
Cedrus deodara	-	-	-
Cornus florida	-	-	+
Diospyros virginiana	-	-	-
Liquidambar styraciflua	-	+	-
Liriodendron tulipifera	+	-	-
Ostrya virginiana	-	-	-
Pinus echinata	+	-	-
P. taeda	+	-	-
Prunus serotina	+	-	-
Quercus alba	-	+	-
Q. falcata	-	-	+
Q. nigra	-	-	+
Q. phellos	-	-	-
Q. stellata	-	-	+
Q. velutina	-	-	+
Ulmus alata	-	-	-
U. americana	-	-	-

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples Licea kleistobolus	L. operculata	Macbrideola cornea
Acer negundo	-	-	-
A. saccharinum	-	+	-
Carya illinoensis	+	-	-
C. ovata	+	+	-
Cedrus deodara	-	-	-
Cornus florida	+	+	-
Diospyros virginiana	-	-	-
Liquidambar styraciflua	-	+	-
Liriodendron tulipifera	+	+	-
Ostrya virginiana	-	-	-
Pinus echinata	-	-	-
P. taeda	-	-	-
Prunus serotina	-	+	-
Quercus alba	+	+	-
Q. falcata	-	-	+
Q. nigra	+	-	-
Q. phellos	-	-	-
Q. stellata	+	+	-
Q. velutina	-	+	-
Ulmus alata	-	-	-
U. americana	-	-	-

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples		
	Macbrideola decapillata	*M. martinii*	*M. synsporos*
Acer negundo	−	+	−
A. saccharinum	−	−	−
Carya illinoensis	−	−	−
C. ovata	−	+	+
Cedrus deodara	−	−	−
Cornus florida	−	−	−
Diospyros virginiana	−	−	−
Liquidambar styraciflua	−	−	+
Liriodendron tulipifera	−	−	−
Ostrya virginiana	−	−	−
Pinus echinata	−	−	−
P. taeda	−	−	−
Prunus serotina	−	−	−
Quercus alba	−	−	−
Q. falcata	−	−	−
Q. nigra	−	−	−
Q. phellos	−	−	−
Q. stellata	+	−	+
Q. velutina	−	−	−
Ulmus alata	−	−	−
U. americana	−	−	−

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples		
	Perichaena chrysosperma	P. minor	Physarum cinereum
Acer negundo	–	–	+
A. saccharinum	–	–	–
Carya illinoensis	+	–	–
C. ovata	+	–	–
Cedrus deodara	–	–	–
Cornus florida	–	–	–
Diospyros virginiana	+	–	–
Liquidambar styraciflua	+	+	–
Liriodendron tulipifera	+	–	–
Ostrya virginiana	+	–	–
Pinus echinata	–	–	–
P. taeda	+	–	–
Prunus serotina	–	–	–
Quercus alba	+	+	–
Q. falcata	+	–	–
Q. nigra	–	–	–
Q. phellos	–	–	–
Q. stellata	+	+	–
Q. velutina	+	–	–
Ulmus alata	+	–	–
U. americana	+	–	–

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples		
	Physarum crateriforme	*P. decipiens*	*P. leucophaeum*
Acer negundo	–	–	–
A. saccharinum	–	–	–
Carya illinoensis	–	–	–
C. ovata	+	+	+
Cedrus deodara	–	–	–
Cornus florida	–	–	–
Diospyros virginiana	–	+	–
Liquidambar styraciflua	–	–	–
Liriodendron tulipifera	–	+	–
Ostrya virginiana	–	–	–
Pinus echinata	–	–	–
P. taeda	–	–	–
Prunus serotina	–	–	–
Quercus alba	+	+	+
Q. falcata	–	–	–
Q. nigra	–	–	–
Q. phellos	–	–	–
Q. stellata	+	+	–
Q. velutina	–	–	–
Ulmus alata	–	–	–
U. americana	–	–	–

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples		
	Physarum nutans	*P. viride*	*Stemonitis axifera*
Acer negundo	+	-	-
A. saccharinum	-	-	-
Carya illinoensis	+	-	-
C. ovata	+	-	-
Cedrus deodara	-	-	-
Cornus florida	+	-	-
Diospyros virginiana	-	-	-
Liquidambar styraciflua	+	-	-
Liriodendron tulipifera	-	+	-
Ostrya virginiana	-	+	-
Pinus echinata	-	-	-
P. taeda	+	+	-
Prunus serotina	+	+	-
Quercus alba	+	-	-
Q. falcata	+	-	-
Q. nigra	+	-	-
Q. phellos	-	-	-
Q. stellata	+	-	+
Q. velutina	-	-	-
Ulmus alata	-	-	-
U. americana	-	-	-

Table 2. (Continued).

Tree Species	Species of Myxomycetes from Bark Samples Stemonitis flavogenita	S. fusca	S. virginiensis
Acer negundo	-	+	-
A. saccharinum	-	+	-
Carya illinoensis	-	+	-
C. ovata	-	+	-
Cedrus deodara	-	-	-
Cornus florida	-	-	-
Diospyros virginiana	-	-	-
Liquidambar styraciflua	-	+	+
Liriodendron tulipifera	-	-	-
Ostrya virginiana	-	-	-
Pinus echinata	-	-	-
P. taeda	-	-	+
Prunus serotina	-	+	-
Quercus alba	+	+	+
Q. falcata	-	-	-
Q. nigra	-	-	-
Q. phellos	-	-	-
Q. stellata	+	+	-
Q. velutina	-	-	-
Ulmus alata	+	+	-
U. americana	-	-	-

to Q. phellos commonly produced slime molds on several pieces in each collection.

None of the myxomycete species found during the course of the study occurred on every tree species sampled. The most ubiquitous myxomycete was Echinostelium minutum. This slime mold appeared on bark from all tree species sampled except Acer negundo, A. saccharinum, Quercus phellos, and Cedrus deodara. Sporangia of Echinostelium minutum varied from sparse to abundant in their occurrence on bark pieces. This species was generally the first to appear in moist chamber culture. Occasionally, however, some other species would develop first, especially when bark collections were made immediately following an extended rainy period. Commonly under such weather conditions, E. minutum sporangia appeared within two or three days after a collection was made. Other species of slime molds that appeared on bark from more than one species of tree were Arcyria cinerea, Badhamia obovata, Calomyxa metallica, Clastoderma debaryanum, Comatricha elegans, C. fimbriata and C. nigra, Cribraria minutissima and C. violacea, Didymium squamulosum, Enerthenema papillatum, Lamproderma scintillans, Licea erecta, L. kleistobolus and L. operculata, Macbrideola synsporos, Perichaena chrysosperma and P. minor, Physarum crateriforme, P. decipiens, P. leucophaeum, P. nutans and P. viride, Stemonitis flavogenita, S. fusca and S. virginiensis. All other species listed in Table 2 occurred on bark of only one of the species of trees used in the study.

Next to Echinostelium minutum, Comatricha fimbriata was the most widespread in occurrence. C. fimbriata was found on bark of 15 tree species. Cribraria minutissima, Didymium squamulosum, and Perichaena chrysosperma were the next most widespread occurring myxomycete species.

They were found on bark of 13 tree species. The other slime mold species, in order of their occurrence on numbers of tree species were Comatricha elegans, which appeared on 12 tree species; Arcyria cinerea, which appeared on 11 tree species; Clastoderma debaryanum, which developed on 10 tree species; and 4 myxomycete species, viz., Cribraria violacea, Licea operculata, Physarum nutans and Stemonitis fusca, each of which appeared on 9 tree species. One species of myxomycete, viz., Licea kleistobolus, was found on bark of 7 tree species. Physarum decipiens was found on 5 tree species. Calomyxa metallica, Enerthenema papillatum, and Physarum viride were found on bark of 4 tree species. Badhamia obovata, Comatricha nigra, Macbrideola synsporos, Perichaena minor, Physarum crateriforme, Stemonitis flavogenita, and S. virginiensis were less widespread in occurrence. They appeared on bark from only three of the tree species studied. Lamproderma scintillans, Macbrideola martinii, and Physarum leucophaeum were found on bark of two of the tree species.

As stated above several species of myxomycetes appeared on similar numbers of tree species but the species of trees on which they occurred differed. For example, Calomyxa metallica, Enerthenema papillatum, and Physarum viride were found on 4 species of trees. They were not all found, however, on the same species of trees. Enerthenema papillatum occurred on bark from Liriodendron tulipifera, Pinus echinata, P. taeda, and Prunus serotina. Calomyxa metallica was found only on bark from Diospyros virginiana, Prunus serotina, Quercus alba, and Ulmus americana. However, in some other cases, slime mold species that occurred on similar numbers of tree species did occur on nearly the same kind of species of trees. For example, like Enerthenema papillatum, Physarum viride appeared on Liriodendron tulipifera, Ostrya virginiana, Pinus taeda, and Prunus serotina. Physarum viride never appeared, however, on Pinus echinata bark, and Enerthenema papillatum never appeared on bark from Ostrya virginiana.

Eleven of the myxomycetes were found on bark of only one species. These species were narrowly restricted in their distribution even though other tree species sampled in this study were in the same plot. Diderma hemisphaericum provides a good example of this situation for this myxomycete appeared often but only on bark from Acer saccharinum. Such was the pattern of distribution for this slime mold even though Acer negundo and Pinus taeda trees stood within a few meters. Comatricha lurida provides another example of restricted distribution for it appeared frequently, during one season, but only on bark from Liriodendron tulipifera. The other species that occurred only on bark from a single tree species were Arcyria nutans and A. carnea, Badhamia nitens, Comatricha pulchella, Didymium difforme, Macbrideola cornea and M. decapillata, Physarum cinereum, and Stemonitis axifera. These myxomycetes appeared infrequently and occurred only in single bark collections (Table 2).

Table 2 also shows the difference noted in number of myxomycete species produced by bark from different tree species. Bark from Quercus alba yielded the largest number of myxomycete species. Twenty-four species were found on white oak bark. The next most productive tree species was Quercus stellata. Twenty-two slime mold species were found on bark from this tree species. Carya ovata was the next most productive tree species for twenty slime mold species developed on bark samples of this species of hickory. The number of slime mold species, in descending order, occurring on bark of the other tree species studied was as follows: 17 from Liquidambar styraciflua, 16 species from Liriodendron tulipifera, 13 from Ulmus alata and Quercus falcata, 9 from Carya illinoensis, 8 from Q. velutina and Acer negundo, 7 from Diospyros virginiana, 6 from Acer saccharinum, Cornus florida, Quercus nigra and Ulmus americana, 5 from Ostrya virginiana and Pinus taeda, and 3 from bark of Cedrus deodara. As previously noted, no slime molds appeared on bark samples taken from Quercus phellos.

Since the bark of the tree species used in this investigation varied significantly in texture and pattern, these features may account, in part, for variations in the myxomycete productivity obtained. It is not known however, what role, if any, differences in bark texture play in the occurrence of corticolous slime molds. An indication of the range of variations in bark surface features that occur between the 21 tree species studied is provided in Figs. 36-49. The bark surface of Pinus taeda is shown in Fig. 36. P. taeda has thick bark that is divided by shallow, irregular fissures into broad, flat-topped plates that separate into smooth, thin, scale-like pieces. Bark samples of P. taeda are easily removed. Pinus echinata bark is broken into irregularly-shaped plates that are covered with thin, smooth scales. Ulmus alata bark, shown in Fig. 37, has flat ridges with closely appressed scales and fissures that are irregular and shallow. This bark was also easy to remove. Bark of Carya ovata, shown in Fig. 38, characteristically separates into thick plates that curl upward at both

Fig. 36. Bark surface of *Pinus taeda*.

Fig. 37. Bark surface of *Ulmus alata*.

Fig. 38. Bark surface of *Carya ovata*.


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Fig. 39. Bark surface of <u>Quercus falcata</u>.

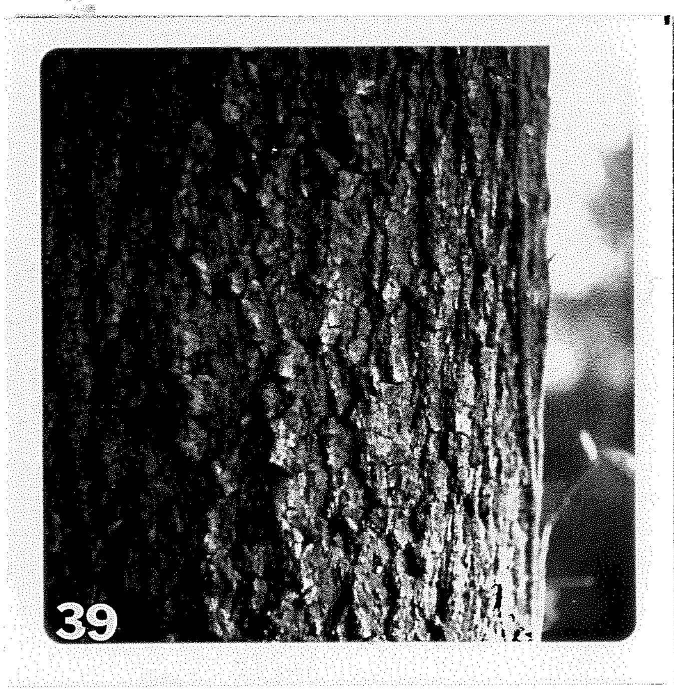
39

Fig. 40. Bark surface of *Quercus alba*.

Fig. 41. Bark surface of *Quercus phellos*.


40


41

Fig. 42. Bark surface of *Ostrya virginiana*.

Fig. 43. Bark surface of *Cedrus deodara*.


42


43

Fig. 44. Bark surface of Diospyros virginiana.


44

Fig. 45. Bark surface of *Cornus florida*.


45

Fig. 46. Bark surface of *Acer saccharinum*.

Fig. 47. Bark surface of *Acer negundo*.


46


47

Fig. 48. Bark surface of Prunus serotina.

Fig. 49. Bark surface of Liriodendron tulipifera.


48


49

ends. The trunk of older trees is rough and shaggy. Bark samples from this species were also easy to remove.

Fig. 39 shows the bark texture of one of the oaks, Quercus falcata. Bark of this oak is deeply fissured and has appressed surface scales. The bark texture of Quercus alba is shown in Fig. 40. White oak bark has flat, loose ridges that are separated by shallow fissures. Fig. 41 shows that the bark of Quercus phellos is relatively smooth with a few irregular cracks. Ostrya virginiana, shown in Fig. 42, has a thin, scaly bark that is easily removed. Cedrus deodara (Fig. 43) has a smooth bark with vertical fissures. This bark is easily removed by peeling. Diospyros virginiana bark is shown in Fig. 44. The characteristic bark pattern of persimmon is one in which there are deep divisions into thick, square plates. Bark from Cornus florida, as shown in Fig. 45, is divided into small scaly blocks, especially on the older trees. Fig. 46 shows Acer saccharinum bark, which is furrowed and separated into large thin scales that are attached in the center and loose at the ends. The bark has a ragged appearance and can be removed in whole plate-like segments. The other maple used in this study was Acer negundo, commonly known as box elder. A. negundo bark is shown in Fig. 47. The bark is deeply divided and has broad scaly ridges. Bark of Prunus serotina is shown in Fig. 48. The bark on this tree is characterized by being thin with horizontal markings made up of rows of lenticels. On older trees the bark is usually in small scaly plates with slightly upraised edges. Bark of Liriodendron tulipifera is closely textured and consists of relatively smooth, vertical ridges (Fig. 49). Sweet gum (Liquidambar styraciflua) has a relatively soft-textured bark, with many vertical, interlacing ridges and furrows.

Seasonal Variations in Occurrence of Species of Corticolous Myxomycetes

Data from this study on the seasonal occurrence of corticolous myxomycetes agree with those that were obtained by the author in a previous study (Pendergrass, 1972). In that study it was determined that moist chamber culture of bark samples produced species of myxomycetes regardless of the season the bark collections were made. Similarly, in this study bark collections made each season throughout the two years of the investigation always yielded fruiting bodies of one or more species of myxomycetes (Table 3). Variations have been noted, however, in the percentage of occurrence and the kinds of species of myxomycetes appearing during the different seasons of the year. For example, Table 1 shows that bark samples collected during the two summer seasons were the most productive in myxomycete yield. During the two summer seasons 540, or 75.1%, of the bark pieces were positive and 179, or 24.9%, of the bark pieces were negative. Collections made during the two spring seasons were second in productivity. For these seasons a total of 372 bark pieces, or 72.5%, were positive and 141 bark pieces, or 27.5%, were negative. Bark collections that were made during the two winter seasons were third in productivity with 434, or 70.6%, of the bark pieces being positive and 181, or 29.4%, being negative. The least productive season, in terms of number of species appearing, was the fall. A total of 366, or 66.9%, of the bark pieces collected during the two fall seasons were positive and 181, or 33.1%, were negative.

Throughout this study substantial variations were noted in the

Table 3. Seasonal distribution of corticolous myxomycetes from bark of trees growing in selected areas within the Atlanta city limits.

Species	Summer 73	Summer 74	Fall 73	Fall 74	Winter 73	Winter 74	Spring 74	Spring 75
Arcyria carnea	-	-	-	-	-	-	-	+
Arcyria cinerea	+	+	+	+	+	+	+	+
Arcyria nutans	-	-	-	-	+	-	-	-
Badhamia nitens	-	-	-	-	-	-	-	+
Badhamia obovata	+	+	-	-	-	-	-	+
Calomyxa metallica	+	-	+	-	-	+	-	+
Clastoderma debaryanum	+	+	+	+	+	+	+	+
Comatricha elegans	+	+	+	+	+	+	+	+
Comatricha fimbriata	-	+	+	+	+	+	+	+
Comatricha lurida	-	-	-	-	-	-	+	-
Comatricha nigra	+	-	-	-	+	+	+	+
Comatricha pulchella	-	-	-	-	-	+	-	-
Cribraria minutissima	+	+	+	+	+	+	+	+
Cribraria violacea	+	+	-	+	+	+	-	+
Diderma hemisphaericum	-	+	-	-	-	+	-	-
Didymium difforme	-	-	-	-	-	+	-	-
Didymium iridis	-	+	-	-	-	-	-	+
Didymium squamulosum	+	+	+	+	+	+	-	+
Echinostelium minutum	+	+	+	+	+	+	+	+
Enerthenema papillatum	-	+	-	-	-	+	-	+

Table 3. (Continued).

Species	Summer 73	Summer 74	Fall 73	Fall 74	Winter 73	Winter 74	Spring 74	Spring 75
Lamproderma scintillans	+	-	+	-	-	-	-	+
Licea erecta	+	+	-	+	+	+	-	+
Licea kleistobolus	-	-	-	+	+	+	-	+
Licea operculata	+	+	+	+	+	+	+	+
Macbrideola cornea	-	+	-	-	-	-	-	-
Macbrideola decapillata	-	-	-	-	-	-	-	+
Macbrideola martinii	+	-	+	-	-	-	-	+
Macbrideola synsporos	+	-	+	-	-	-	-	+
Perichaena chrysosperma	+	+	+	+	+	+	+	+
Perichaena minor	-	-	-	-	+	+	+	+
Physarum cinereum	-	-	-	+	-	-	-	-
Physarum crateriforme	-	-	-	-	-	-	+	+
Physarum decipiens	+	+	-	+	+	+	-	+
Physarum leucophaeum	+	+	+	-	-	-	-	-
Physarum nutans	+	+	+	+	+	+	+	+
Physarum viride	+	-	-	+	-	-	-	+
Stemonitis axifera	+	-	-	-	-	-	-	-
Stemonitis flavogenita	-	-	-	-	-	+	-	+
Stemonitis fusca	+	+	-	+	+	+	-	-
Stemonitis virginiensis	+	-	-	-	+	-	-	+

number of species of slime molds appearing on incubated bark samples in the spring, summer, fall and winter seasons. Data on seasonal variations of species are presented in Table 3. As shown in the table, eight of the 40 species recorded appeared on bark samples each of the four seasons during the two-year period of the study. Some species appeared on bark samples collected during a given season of one year but failed to appear on samples collected the same season of another year. For example, *Didymium squamulosum* was found throughout the entire collecting period, except for the spring of 1974. Another species, *Comatricha fimbriata*, appeared on bark samples collected each season over the two-year period of study, except for the summer of 1974. It can also be noted in Table 3 that some species appeared during one season of one year and failed to appear during any other season or during the same season of the other year. For example, *Arcyria nutans* was not found during the winter of 1974 although it was found during the winter of 1973. Other species that exhibited similar distributional patterns were *Comatricha lurida*, *C. pulchella*, *Didymium difforme*, *Macbrideola cornea*, *M. decapillata*, *Physarum cinereum*, and *Stemonitis axifera*.

Seasonal variations were also noted when numbers of fruiting bodies formed on bark samples by a given species were observed. Fruiting bodies of *Arcyria cinerea*, *Comatricha elegans*, *C. fimbriata*, *Cribraria minutissima*, *Echinostelium minutum*, *Licea operculata*, and *Physarum nutans* varied in abundance during the four seasons. Fruiting bodies of these species were common on bark samples collected during the spring and summer seasons. They were relatively sparse on bark samples collected during the fall and winter seasons. Although these observations suggest a probable seasonal influence in the development of some slime mold species, definite conclusions cannot be drawn at this point. These findings compare favorably, however, with those obtained in previous studies from this region on corticolous myxomycete occurrence (Ku, 1969; Pendergrass, 1972).

Myxomycete Occurrence on Fallen Debris

In order to obtain further information on the question regarding bark of living trees as a natural substrate for myxomycete occurrence, observations were made on myxomycetes occurring on fallen plant debris in two of the five collecting localities used in this study. Debris was examined primarily to determine whether the same species of slime molds that appeared in moist chamber on bark pieces taken from trees growing in the plot would also be found as a part of the natural bionta of fallen debris in that same area. It was assumed that spores of slime molds found on the tree bark should also be present on debris on the forest floor. The characteristic absence of the bark colonizing species from forest floor litter would suggest that living tree bark may well represent a distinct ecologic niche for the corticolous myxomycetes.

The localities used in this part of the study were the Collier Heights and Beecher Circle areas. They were chosen because they had an abundance of fallen debris under the forest canopy. Similar material in the Collier Heights locality was examined extensively three times during the course of this study. It was examined once in the fall of 1973, once during the summer of 1974, and once during the spring of 1975. There were no extensive winter observations of forest floor litter. Casual observations were made, however, when bark samples were being collected from trees during the winter seasons. In the Collier Heights locality some slime mold species were found that were common to bark from living trees as well as to fallen debris. These species were Arcyria cinerea, Physarum cinereum, P. viride, and Stemonitis fusca. Hemitrichia stipitata was commonly found on fallen debris in this locality but never appeared on bark samples from living trees.

The Beecher Circle locality, as previously indicated, is relatively moist throughout the year and creates, therefore, a highly favorable environment for myxomycete development. The variety of species and abundance of fruiting bodies found on debris in this locality attested to the conduciveness of the environment. Whereas only five species were found on fallen debris in the Collier Heights locality, by comparison, 13 species were collected on similar substrate in the Beecher Circle locality. Field observations were made in this locality on the same dates that similar observations were made in the Collier Heights locality. The species of slime molds collected were as follows: Acryria cinerea and A. nutans, Ceratiomyxa fruticulosa, Dictydium cancellatum, Fuligo septica, Hemitrichia stipitata, Lycogala epidendrum, Metatrichia vesparium, Physarum cinereum, P. nutans and P. viride, Stemonitis axifera and S. fusca. The species of myxomycetes that appeared on living tree bark as well as on debris in the Beecher Circle locality were Arcyria cinerea, A. nutans, Physarum cinereum, P. nutans and P. viride, Stemonitis axifera and S. fusca. The other species were found only on leaf litter.

Data from this study reveal that some myxomycete species will develop on bark of living trees as well as on leaf litter and that some species apparently will appear only on bark of living trees or only on fallen debris. It appears as if only certain myxomycete species such as *Arcyria cinerea*, *A. nutans*, *Physarum cinereum*, *P. nutans*, *P. viride*, *Stemonitis axifera* and *S. fusca*, will grow both on debris and on bark of living trees. It appears also that species with smaller fruiting bodies such as *Comatricha fimbriata*, *C. elegans*, *Cribraria minutissima* do not commonly develop on forest floor debris. *Echinostelium minutum* is unique in this respect for it appears on a variety of substrata, including fallen debris. Probable reasons for this pattern of ecological distribution for small fruiting-body species will be considered later.

Additional Techniques for Studying Corticolous Myxomycete Occurrence

In order to gain further information on the question as to whether bark of living trees is a natural substratum for myxomycete occurrence, bark from some tree species was studied under conditions that better approximated natural conditions. As indicated under Materials and Methods, one of these techniques involved removing bark samples from a tree and placing them in petri plate moist chambers that were left in the field at the base of the tree. Simultaneously, bark pieces were removed from the same trees and incubated in moist chambers under laboratory conditions. This practice was followed in order to determine whether the same slime molds that appeared on those bark pieces collected and left under natural conditions would also appear on those bark pieces held under laboratory conditions. Another modification involved placing detached bark pieces in plastic bags, moistening them with distilled water, and attaching the bags to the trees from which the samples were taken.

For this part of the study, 4 tree species were used. The species were Pinus taeda, Diospyros virginiana, Liquidambar styraciflua, and Prunus serotina. Some of these trees were within one to one and a half meters of each other while others were more widely separated.

Under laboratory conditions moist chamber cultures of bark from the four tree species used produced six species of slime molds. These species were Arcyria cinerea, Comatricha elegans, Echinostelium minutum, Enerthenema papillatum, Licea erecta, and Physarum nutans. Three species developed within the same time period on bark pieces in petri dishes left under field conditions. They were Arcyria cinerea, Comatricha elegans, and Echinostelium minutum. With the exception of Enerthenema papillatum, Licea erecta, and Physarum nutans, the same myxomycete species that appeared under laboratory conditions also appeared under field conditions. Only two species of slime molds appeared on the bark pieces placed in the plastic bags and left attached to the trees. Those species were Comatricha elegans and Echinostelium minutum. Both of these species appeared under field and laboratory conditions in moist chamber culture.

Another method used to provide additional information on the question regarding bark of living trees as a natural substratum for myxomycetes involved the plastic bag-drip technique. As described previously, plastic bags attached at about breast height to trees were filled with water and perforated at the bottom with several pin holes. This enabled water to slowly drip from the bag onto the bark below. This way an area of undisturbed bark was kept moist continuously. Observations made about 14 days after the beginning of the experiment revealed that sporangia of Comatricha elegans were present below the bag on one of the pine trees. Even though Comatricha elegans was the only slime mold species noted on the moist bark below the plastic bags the appearance of this species strongly suggested that if moisture requirements are met certain species of slime molds will probably develop commonly under natural conditions on living tree bark. The appearance of C. elegans under the conditions provided prompted further careful examination of bark of other trees in the area for slime mold presence. No other fruiting bodies were noted at the time C. elegans was found on the artificially moistened tree trunk. However, in July, 1975, after a night of continuous rain, preceded by nearly 4 days of intermittent drizzling, field observations revealed the presence of several immature fruiting bodies on all the loblolly pine trees in the area, including those that had not been continuously moistened artificially.

Bark of those trees with plastic bags attached were covered with slime mold fruiting bodies both below and above the bags. Those trees not treated also had numerous fruiting bodies on their bark surfaces. The slime molds occurred at all levels observed, that is, from less than a meter above ground to a height of over 2 meters. Although observations were not made above the highest level indicated, it may be that they were also present at higher levels on the tree trunks. The immature fruiting bodies appeared on all sides of the trees but were more abundant on their northwest sides, the side away from direct sunlight. At the time the sporangia were initially observed they were watery or milky white in appearance. Some others had a reddish, watery appearance. They all appeared to have, however, the plate-like structure on top of the sporangial heads that is characteristic of *Enerthenema papillatum*. Later, when these fruiting bodies matured, they were determined to be those of *Enerthenema papillatum* (Fig.34).

All examinations of tree trunks were made in the morning between the hours of 9 and 12. Some of the areas containing immature fruiting bodies were marked. Later observations revealed that many of the immature fruiting bodies had matured. Some, however, remained immature, probably as a result of the drying effect of the sunlight. Even though some areas where immature fruiting bodies were noted were initially marked, when observed later, it was discovered that these fruiting bodies were difficult to locate. It was clear, therefore, that if one were to examine only unmarked areas of the tree trunk fruiting bodies of slime molds could easily be overlooked.

Sporangia of *Arcyria cinerea* were also observed on one of the trees but only in a place on the trunk below the point where a dripping plastic bag had been attached. This area on the tree maintained a high moisture level whereas other areas of the tree were almost completely dry. By comparison, the distribution of *Enerthenema papillatum* was much more widespread, for this species was found on all the trees within a 3-4 meter radius of the experimental trees. As a result of the use of the plastic bag-drip technique 2 species of myxomycetes, *A. cinerea* and *E. papillatum*, were found growing naturally on the bark of standing trees.

Check-List of Corticolous and Non-corticolous Myxomycetes From Urban Areas in the Atlanta Metropolitan Region

Bark of living trees appears to provide a unique habitat for certain myxomycete species. The species found growing in this kind of substratum appear to be generally distinctive and may be described as "corticolous". Observations that were made during the period from June 1973 to June 1975 have resulted in the collection of a total of 46 species. Forty of these species are corticolous and six are non-corticolous. The corticolous species are, for the most part, small sporangiate forms. Some, however, are plasmodiocarpous and some are aethaloid. The latter occur with much less frequency.

The species found represent 11 families of myxomycetes. Several variations have been noted in the abundance of slime mold representation by families. The family *Echinosteliaceae* has been found to be the most common. Members of this family form the smallest fruiting bodies with the simplest structure of all the known acellular slime molds. The next family with the most abundant representation was *Stemonitaceae*. Members of this family are more variable than the *Echinosteliaceae* in fruiting body size. Some are minute in size, as those in the genus *Macbrideola*, and some form larger more macroscopic fruiting bodies such as are found in some species of *Stemonitis*. The other families represented in this study were *Ceratiomyxaceae*, *Clastodermataceae*, *Cribrariaceae*, *Dianemaceae*, *Didymiaceae*, *Liceaceae*, *Physaraceae*, *Reticulariaceae* and *Trichiaceae*. The family *Clastodermataceae* was recently established by Alexopoulos and Brooks (1971).

Some of the species of myxomycetes found in this study represent new records of occurrence for the state of Georgia. Calomyxa metallica, Clastoderma debaryanum, Badhamia nitens, B. obovata, Licea erecta, Macbrideola cornea, M. decapillata, M. martinii, and M. synsporos, Perichaena minor, Physarum crateriforme, P. decipiens and P. leucophaeum are species previously unreported from the state. This is apparently the first report of Licea erecta in the western hemisphere.

Where difficulties were encountered in the determination of some species, the assistance of Dr. Marie Farr, Mycology Laboratory, U.S.D.A. Agricultural Research Services, Northeastern Region, Agricultural Research Center, Beltsville, Maryland, Dr. Harold Keller, Wright State University, Dayton, Ohio and Dr. Donald Kowalski, Chico State College, Chico, California was sought.

The species found in this study are grouped below under the family name. All taxa are alphabetically arranged. Non-corticolous myxomycetes are starred (*).

CERATIOMYXACEAE

This family has recently been placed by Olive (1975) into the Protostelida.

*Ceratiomyxa fruticulosa (Mull.) Macbr.

This species occurred only on leaf litter and decaying logs. It was found throughout the two years of this study in the Collier Heights and the Beecher Circle localities. C. fruticulosa was very common in occurrence during all the seasons in which observations were made.

CLASTODERMATACEAE

Clastoderma debaryanum Blytt. Fig. 50

This species was common on bark of Liriodendron tulipifera and

Fig. 50. Sporangium of *Clastoderma debaryanum* on bark of *Liriodendron tulipifera*. 13.76X


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Acer saccharinum. It also appeared frequently on bark of *Quercus alba*, *Q. stellata* and *Q. velutina*, *Carya ovata*, *Cornus florida*, *Prunus serotina*, and *Liquidambar styraciflua*. *C. debaryanum* occurred throughout the two-year period of study but only on bark of living trees. It is reported, however, to occur on other substrata such as dead wood and miscellaneous debris. In addition to being present on bark samples collected during all seasons of the study, *C. debaryanum* appeared in all of the localities investigated with the exception of Piedmont Park. This family was established by Alexopoulos and Brooks (1971) on the basis of sporocarp development and plasmodial type. The rationale was that *Clastoderma* and *Barbeyella*, another species closely related to *Clastoderma*, like *Echinostelium*, have a subhypothallic developmental pattern and a plasmodial stage that is a protoplasmodium, as in the case of all species of *Echinostelium*. As a result of these characters, they proposed erecting a new family, the *Clastodermataceae*, and placed it in the order Echinosteliales.

CRIBRARIACEAE

Cribraria minutissima Schw.

This species was very abundant in occurrence especially on bark samples from *Pinus taeda* throughout the two-year period of study. It was found also on bark from several other tree species, namely, *Carya illinoensis* and *C. ovata*, *Cedrus deodara*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Ostrya virginiana*, *Prunus serotina*, *Quercus alba*, *Q. falcata*, *Q. stellata*, *Q. velutina*, and *Ulmus alata*. *C. minutissima* is also reported from non-corticolous substrata such as dead wood and moss. It was found in all five of the localities used in this study.

Ku (1969) reported that during the period of his study this species was found mostly on bark of loblolly pine and once on bark from winged elm. Even though C. minutissima was abundant in occurrence on conifer bark, in this study it was also abundant in occurrence on some of the hardwood tree species sampled.

Cribraria violacea Rex.

This species was found on bark of Carya illinoensis and C. ovata, Liquidambar styraciflua, Ostrya virginiana, Quercus alba and Q. stellata, Ulmus alata and U. americana. It was more common, however, on bark samples of Liriodendron tulipifera. C. violacea is reported from other substrata such as dead wood, bark of dead trees, and on mosses. In this study it was found on bark samples from trees in all the collecting localities with the exception of one, Washington Park. This species was found during the fall of 1974, the winter of 1973 and 1974, spring of 1975, and the summer of 1973 and 1974.

*Dictydium cancellatum (Batsch) Macbr.

This species was found only on leaf litter. It has been reported from dead wood. D. cancellatum was never found on bark of living trees during this study. When observed it was found in the Beecher Circle locality each time observations were made, regardless of whether it was during the spring, summer, winter, or fall.

DIANEMACEAE

Calomyxa metallica (Berk) Nieuwl. Fig. 51

This is the first report of the occurrence of this species in Georgia. C. metallica was found on bark of Diospyros virginiana, Liriodendron tulipifera, Quercus alba, and Ulmus americana. It appeared

Fig. 51. Sporangium of *Calomyxa metallica* on bark of *Liriodendron tulipifera*. 13.76X


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infrequently throughout the two-year study. C. metallica is reported from other substrata such as rotten wood and bark. In this study it occurred in 4 of the localities studied, viz., Washington Park, Piedmont Park, Collier Heights, and the Highpoint locality. It appeared during the fall of 1973, the winter of 1974, the spring of 1975, and the summer of 1973.

DIDYMIACEAE

Diderma hemisphaericum (Bull.) Hornem

This species appeared on bark of Acer saccharinum during the summer and winter of the second year of this study. D. hemisphaericum has been reported from a variety of substrata such as leaf litter and dead wood. In this study it was found only in the Highpoint locality.

Didymium difforme (Pers. S. F. Gray) Fig. 52

This species appeared once on bark from Quercus stellata in the Collier Heights locality. In the literature, D. difforme is reported from a variety of substrata.

Didymium iridis (Ditmar) Fries Fig. 53

This species was very common on bark of Acer negundo. It occurred during the summer of 1974 and the spring of 1975. No fruiting bodies were found on bark collected during the fall and winter months. D. iridis is a widespread species and is reported from other substrata such as dead leaves, mosses, twigs, dead wood, and occasionally old dung. It was found only on bark samples from trees in the Highpoint locality.

Didymium squamulosum (Alb. & Schw.) Fries Fig. 54

This species was commonly found on bark samples of several trees

Fig. 52. Sporangium of _Didymium_ _difforme_ on bark of _Quercus_ _stellata_. 13.76X


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Fig. 53. Sporangia of *Didymium iridis* on bark of *Acer negundo*. 13.76X


53

Fig. 54. Sporangia of _Didymium squamulosum_ on bark of _Carya ovata_. 9.25X

54

throughout the investigation except for the spring of 1974. Fruiting bodies appeared on bark samples from Acer negundo and A. saccharinum, Carya illinoensis and C. ovata, Cornus florida, Diospyros virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Pinus taeda, Quercus alba, Q. falcata, Q. nigra and Q. stellata. D. squamulosum is reported from other substrata such as dead plant remains of all sorts and on dung of herbivorous animals. It was found in all the localities studied.

ECHINOSTELIACEAE

Echinostelium minutum de Bary

This species represents the only member of this family found during the period of the study. E. minutum was the most commonly occurring species. It appeared on bark from all of the trees sampled except Acer negundo and A. saccharinum, Cedrus deodara, and Quercus phellos. E. minutum appeared throughout the study during all seasons, and in every locality used for this study. This species is reported from a variety of substrata.

LICEACEAE

Licea erecta Thind & Dhillon Fig. 55

The report of the presence of this species represents a new record for the state and for the western hemisphere. Heretofore this species was known only from the type locality in India. L. erecta occurred on bark of seven tree species with fruiting bodies appearing more abundantly and frequently on Cornus florida. This slime mold also appeared on bark from Acer saccharinum, Carya ovata, Quercus falcata, Q. nigra, Q. stellata, and Q. veluntina. L. erecta was originally reported from decaying bamboo stems. It appeared on Cornus florida bark samples in

Fig. 55. Sporangia of Licea erecta on bark of Acer saccharinum. 11.20X

55

all of the localities studied. *L. erecta* appeared during the fall of 1974, the winter of 1973 and 1974, the spring of 1975, and the summer of 1973 and 1974.

Licea kleistobolus Martin Fig. 56

This *Licea* species occurred frequently on bark of *Cornus florida*, *Liriodendron tulipifera*, *Quercus alba*, *Q. nigra*, *Q. stellata*, *Ulmus alata* and *U. americana*, with bark of no one species being more productive than the others. In the literature *L. kleistobolus* is reported from dead wood and bark, especially on conifers. It was found in all of the localities studied except Collier Heights. This species of *Licea* occurred during the fall of 1974, the winter of 1973 and 1974, and the spring of 1975. It was not found during either of the two summer seasons of the two-year period of study.

Licea operculata (Wingate) Martin

This species was common on *Cornus florida* and *Prunus serotina*, and frequently appeared on bark of *Acer saccharinum*, *Carya ovata*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Quercus alba*, *Q. stellata*, and *Q. velutina*. *L. operculata* was found during all seasons and in all the localities studied. This species has been reported mainly from bark and less commonly from leaves.

PHYSARACEAE

Badhamia nitens Berk. Fig. 57

This species represents a new record for the state. *B. nitens* was found once on a bark sample of *Liquidambar styraciflua* collected during the spring of 1975 in the Highpoint locality. In the literature it is reported to occur on a variety of substrata.

Fig. 56. Sporangia of *Licea kleistobolus* on bark of *Liriodendron tulipifera*. 20.81X


56

Fig. 57. Sporangium of _Badhamia nitens_ on bark of _Liquidambar styraciflua_. 13.76X

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Badhamia obovata (Peck) S. J. Smith Fig. 58

This species also represents a new record for the state. B. obovata appeared on bark of Carya ovata, Ostrya virginiana, and Quercus alba. It appeared during the summers of 1973 and 1974 and during the spring of 1975. B. obovata is reported as common on substrata such as rotten wood and plant debris. It was found on bark collected from trees in the Beecher Circle locality.

*Fuligo septica (L.) Wiggers.

This very common slime mold species was found on leaf litter and rotten wood in the Beecher Circle locality. It never appeared on bark samples in moist chamber culture.

Physarum cinereum (Batsch) Pers.

This commonly occurring species appeared once in moist chamber culture on a bark sample of Acer negundo from the Highpoint locality. It was observed on several occasions, however, on plant debris on the forest floor of plots in this and two other localities. P. cinereum is known from a variety of substrata. This species appeared on bark samples collected during the fall of 1974.

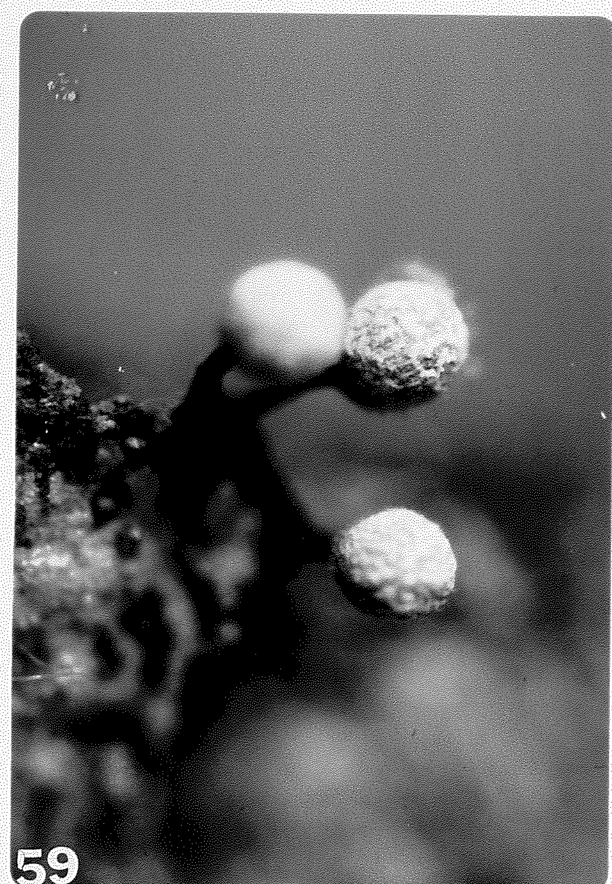
Physarum crateriforme Petch. Fig. 59

P. crateriforme was common on bark of Carya ovata, Quercus alba, and Q. stellata. It appeared only during the spring of both years of the study. This is the first report of this species in the state. P. crateriforme appeared on bark samples from the Collier Heights, Beecher Circle, and Highpoint localities. Dead wood and decaying stems of herbaceous plants are the principal substrata on which this species has been noted. Identification of this species was confirmed by Dr. Marie

Fig. 58. Sporangia of _Bahamia obovata_ on bark of _Carya ovata_.
13.76X


58

Fig. 59. Sporangia of _Physarum crateriforme_ on bark of _Carya ovata_. 13.76X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Farr.

Physarum decipiens Curtis Fig. 60

Fruiting bodies from this species appeared on bark samples taken from Carya ovata, Diospyros virginiana, Liriodendron tulipifera, Quercus alba and Q. stellata. P. decipiens is reported from other substrata such as dead wood and mosses. This species appeared throughout the study with the exception of the fall of 1973 and the spring of 1974. It represents a new record for the state of Georgia and was found on bark samples from trees in three localities, viz., Washington Park, Collier Heights, and Beecher Circle.

Physarum leucophaeum Fries. Fig. 61

This species of Physarum represents another new record for Georgia myxomycetes. It appeared on bark samples from Carya ovata and Quercus alba growing in the Beecher Circle locality during the fall of 1973 and the summer of 1973 and 1975. This species is known from other substrata such as dead wood and leaves. Identity of this species was confirmed by Dr. Marie Farr.

Physarum nutans Pers. Fig. 62

P. nutans was one of the most common myxomycete species found during the course of this study. It appeared on bark from nine of the tree species sampled and occurred throughout the two-year period of study during all seasons. This species was also confirmed by Dr. Marie Farr. P. nutans is known from substrata such as dead wood and old fungal fruiting bodies. It appeared on bark from Acer negundo, Carya illinoensis, C. ovata, Cornus florida, Liquidambar styraciflua, Pinus taeda, Prunus serotina, Quercus alba and Q. stellata in all five localities.

Fig. 60. Sporangia of *Physarum decipiens* on bark of *Carya ovata*.
11X


60

Fig. 61. Sporangia of _Physarum leucophaeum_ on bark of _Carya ovata_. 9.80X

61

Fig. 62a. Sporangia of *Physarum nutans* on bark of *Quercus nigra*.

15.40X


62a

Fig. 62b. Sporangia of *Physarum nutans* on bark of *Quercus nigra*.
15.40X


62b

Physarum viride (Bull.) Pers.

This was a common species that appeared frequently on bark samples from Liriodendron tulipifera, Ostrya virginiana, Pinus taeda and Prunus serotina. This species is recorded on other substrata such as dead wood, old sporophores of fungi, and less commonly on leaves and herbaceous debris. P. viride appeared on bark samples of the four species of trees in all five localities and was found during the summer of 1973, the fall of 1974, and the spring of 1975.

RETICULARIACEAE

*Lycogala epidendrum (L.) Fries

This common species occurred only on forest floor debris and never on bark of living trees. It was usually found during the fall, spring, and summer when field examinations of plant debris in plots in the Beecher Circle locality were made.

STEMONITACEAE

Comatricha elegans (Racib.) G. Lister

This species was often encountered on bark of Carya ovata, Cedrus deodara, Liquidambar styraciflua, Liriodendron tulipifera, Pinus taeda, Prunus serotina, Quercus alba, Q. nigra, Q. stellata, and Ulmus alata. C. elegans was more commonly observed on bark of Pinus taeda where it was found in situ as well as in moist chamber culture. It appeared during all seasons of this study and in each of the localities.

Comatricha fimbriata G. Lister & Cran

This species occurred each season throughout the study on bark samples from 15 of the 22 species of trees in each locality. Bark from Acer saccharinum, Cornus florida, Ostrya virginiana, Quercus nigra, Q.

phellos and Q. velutina did not produce C. fimbriata. This species is known to occur on a variety of other substrata.

Comatricha lurida A. Lister

C. lurida was found once during the study. It appeared during the spring of 1974 on bark samples from Liriodendron tulipifera growing in Piedmont Park. Leaves are the only other substrata from which this myxomycete has been reported.

Comatricha nigra (Pers.) Schroet.

This species appeared frequently on bark samples from Pinus taeda, Carya ovata, and Quercus velutina. C. nigra was found on bark samples of these tree species collected in Piedmont Park, Collier Heights, and the Highpoint locality during the winter of 1973 and 1974, the spring of 1974 and 1975, and the summer of 1973. Dead wood is reported to be the typical substratum for this species.

Comatricha pulchella (Bab.) Rost.

C. pulchella was rare in occurrence. A single fruiting body appeared on a bark sample of Quercus alba collected during the winter of 1974 from a tree in Washington Park. This species has been reported from a variety of other substrata.

Enerthenema papillatum (Pers.) Rost. Fig. 63

Fruiting bodies of this species occurred only during the summer, winter, and spring of 1974. It was not found during the first year of the study. E. papillatum appeared on bark samples from Pinus echinata, P. taeda, and Liriodendron tulipifera. It was also observed in situ on Pinus taeda. E. papillatum was found in each locality except Piedmont Park. Dead wood and bark are the other substrata on which this species

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is known to occur.

Lamproderma scintillans (Berk. & Br.) Morgan

This species was encountered three times during the course of this study. It appeared once during the summer of 1973, during the fall of the same year, and during the spring of 1975. L. scintillans was found only on bark from Liquidambar styraciflua and Quercus alba and occurred only in the Beecher Circle and Highpoint localities. This species has been reported from a variety of other substrata.

Macbrideola cornea (G. Lister & Cran) Alexop. Fig. 64

M. cornea represents another new record for the state of Georgia. It was found once during the course of this study and that appearance occurred in Piedmont Park. A bark sample from Quercus falcata in Piedmont Park yielded fruiting bodies of this myxomycete during the summer of 1974. Tree bark and moss are the substrata from which this species is known.

Macbrideola decapillata H. C. Gilbert Fig. 65

The report of this species also represents a new record for the state. M. decapillata appeared only during the spring of 1975 on bark samples from Quercus stellata growing in the Beecher Circle locality. Bark is the only type substratum from which this species has been reported.

Macbrideola martinii (Alexop. & Beneke) Alexop. Fig. 66

Fruiting bodies of this species appeared once during the summer and fall of 1973 and the spring of 1975. It was found on bark samples of Carya ovata and Acer negundo. M. martinii appeared only on bark collected from trees growing in the Highpoint and Piedmont Park

Fig. 64. Sporangium of *Macbrideola cornea* on bark of *Quercus falcata*. 13.76X


64

Fig. 65. Sporangium of *Macbrideola decapillata* on bark of *Carya ovata*. 13.76X

65

Fig. 66. Sporangium of _Macbrideola martinii_ on bark of _Acer negundo_.


66

localities. This is the first report of this species in Georgia.

Macbrideola synsporos (Alexop.) Alexop. Fig. 67

This species appeared infrequently on bark samples collected from Carya ovata, Liquidambar styraciflua, and Quercus stellata. M. synsporos is known only from living tree bark in moist chamber culture. It was found on bark from trees growing in 3 of the localities used in this investigation, viz., Collier Heights, Piedmont Park, and Washington Park. It appeared during the fall of 1973, the summer of 1973, and the spring of 1975. The report of this species also represents a new Georgia record.

Stemonitis axifera

This species of Stemonitis is common in field collections. It also appeared in moist chamber culture. A bark sample collected during the summer of 1973 from a tree growing in Washington Park, produced fruiting bodies of S. axifera. Dead wood is the only substratum from which this myxomycete has been reported.

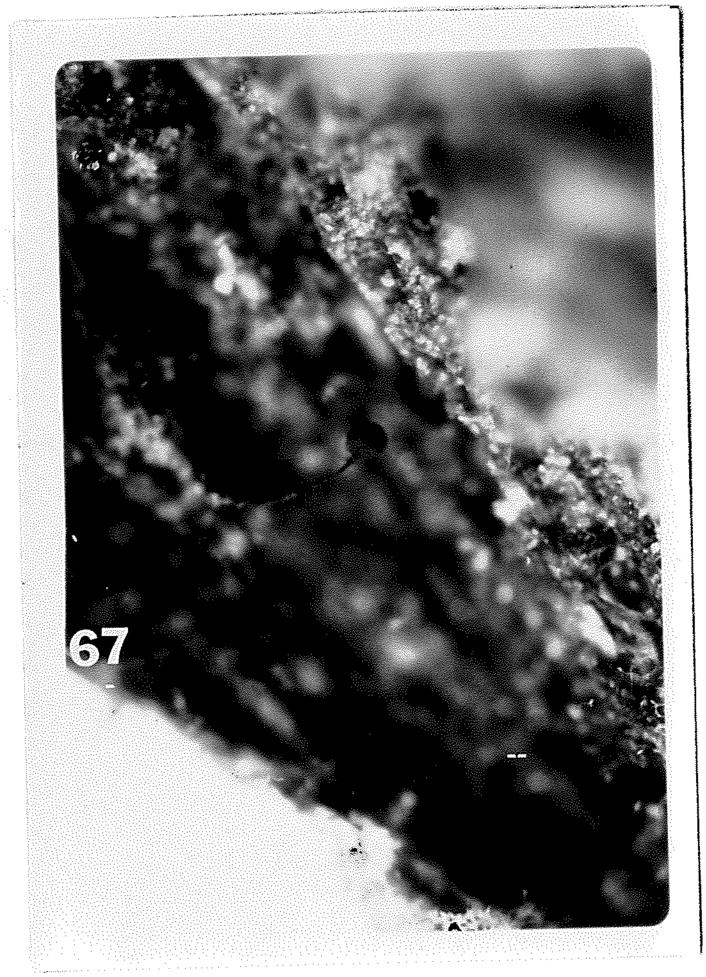
Stemonitis flavogenita Jahn.

S. flavogenita appeared on bark samples from Ulmus alata and Quercus stellata. When this species appeared during the winter of 1974 and spring of 1975 it formed sporangial clusters. Usually there was one cluster on a piece of bark when found. This species is reported from other substrata such as dead wood and plant debris. S. flavogenita developed on bark samples from trees growing in the Collier Heights, Highpoint, Piedmont Park, and Washington Park localities.

Stemonitis fusca Roth.

This widespread, typically non-corticolous, species was very common

Fig. 67. Sporangium of _Macbrideola synsporos_ on bark of _Carya ovata_. 13.76X



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on bark from Acer negundo, A. saccharinum, Carya illinoensis, C. ovata Liquidambar styraciflua, Prunus serotina, Quercus alba, Q. stellata, and Ulmus alata. Sporangia were characteristically clustered when found. S. fusca was found on bark samples collected in all localities except Washington Park. S. fusca appeared during the fall of 1974, the winter of 1973 and 1974, and the summers of 1973 and 1974. It did not appear in moisture chamber culture of bark collected during the spring of either year.

Stemonitis virginiensis Rex.

This species appeared three times on bark from Liquidambar styraciflua, Pinus taeda and Quercus alba. It was found twice during the summer and winter of the first year of this study and once during the spring of the second year. Bark samples from the Beecher Circle and Collier Heights localities produced this species.

TRICHIACEAE

Arcyria carnea (G. Lister)

A. carnea appeared once during this study. A bark sample from Quercus alba in the Collier Heights locality yielded one cluster of fruiting bodies of this slime mold. Dead wood is the only substratum from which this myxomycete has been reported previously. A. carnea was found during the spring of 1975.

Arcyria cinerea (Bull.) Pers.

This species was common on bark samples from Carya ovata, Diospyros virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Pinus taeda, Prunus serotina, Quercus alba, Q. falcata, Q. velutina, and Ulmus alata. A. cinerea is a common slime mold and has been reported from a variety of other substrata. This species was also observed in situ on Pinus taeda bark. It occurred in all of the areas selected for this study and during every season of each year that the study was conducted.

Arcyria nutans (Bull.) Grev.

This species appeared once on bark of Pinus taeda. It was found during the winter of 1973. The only other substratum from which A. nutans has been reported is dead wood. Bark from the Beecher Circle area produced this species.

*Hemitrichia stipitata (Massee) Macbr.

This myxomycete species was frequently found on twigs and other plant debris on the forest floor. It never appeared on bark samples in moist chamber culture. H. stipitata is reported mainly from dead wood. It was found in the fall, spring and summer of each year of the study, whenever leaf litter was examined.

*Metatrichia vesparium (Batsch) Nann-Brem.

This species was very common on leaf litter of the localities examined. M. vesparium is reported from a variety of other substrata. It was found in the Beecher Circle area each season of the two-year study.

Perichaena chrysosperma (Currey) A. Lister

This species appeared abundantly each season in each locality throughout the two-year study. Bark samples from Carya illinoensis, C. ovata, Diospyros virginiana, Liquidambar styraciflua, Liriodendron tulipifera, Ostrya virginiana, Pinus taeda, Quercus alba, Q. falcata, Q. stellata, Q. velutina, Ulmus alata and U. americana produced P.

Fig. 68. Sporangium of *Perichaena minor* on bark of *Quercus alba*. 13.76X

chrysosperma. This species has been reported on a variety of other substrata.

Perichaena minor (G. Lister) Hagelst Fig. 68

The occurrence of P. minor represents a new record for the state. P. minor appeared on bark samples from Liriodendron tulipifera and Quercus stellata. It appeared only during the winter and spring seasons of the two-year period of study. Bark from the Collier Heights and Beecher Circle localities produced P. minor.

CHAPTER V

DISCUSSION

This study on corticolous myxomycetes from selected trees growing in five different localities within metropolitan Atlanta increases our general knowledge of the myxomycete bionta of the state of Georgia and furthers our understanding of the relationship of these organisms to a rather unique ecological niche. The results obtained in this study, relative to the general occurrence of myxomycetes on bark of living trees, substantially agree with the findings of others who have conducted similar studies (Gilbert and Martin, 1933; Peterson, 1952; Brooks, 1967; Ku, 1969; Pendergrass, 1972). It becomes increasingly evident, therefore, that bark represents a substratum that supports a highly distinctive group of myxomycete species in nature. Some of these forms may very well be restricted to bark of living trees.

Data from this study reveal that some myxomycete species will develop on bark of living trees as well as on fallen debris and that some species apparently will appear only on bark of living trees or only on fallen debris. It appears also that species with smaller fruiting bodies such as *Comatricha fimbriata*, *C. elegans* and *Cribraria minutissima* do not commonly develop on forest floor debris. *Macbrideola synsporos* represents another example of a smaller form found in this study, and it is a species that is known only from bark of living trees. Brooks (1967) has suggested that in nature it is highly probable that this species typically grows only on tree bark. This may be the case because of the type of plasmodia produced by the slime molds with smaller fruiting bodies or the lack of competition from more aggressive organisms growing on bark of living trees.

Not only does it appear as if living tree bark may be the characteristic substratum for some myxomycete species, data from previous studies of mine (Pendergrass, 1972) and Ku (1969) suggest that in a given locality certain species may consistently occur on bark of a particular species of tree. In Ku's study, four species of trees were regularly sampled over a one year period. Three of the tree species used by Ku, viz., *Pinus taeda*, *Quercus alba*, and *Ulmus alata*, were included in this study. Ku reported *Comatricha fimbriata* as abundant on bark of *Pinus taeda* and absent from bark samples taken from the other species of trees that he studied. The trees studied by Ku grew in two different localities, one an urban and the other a suburban locality. The trees sampled in each locality stood within a few meters of each other. In my earlier study (Pendergrass, 1972), *C. fimbriata* failed to appear on bark samples of the several loblolly pine trees that were sampled. In that study it did appear, however, on bark samples collected from *Quercus falcata*. In the study reported here *C. fimbriata* appeared abundantly on *Pinus taeda* bark, and on bark of *Quercus alba* and *Ulmus alata*. Also, in this study *Comatricha fimbriata* appeared on bark samples of 12 other tree species including *Quercus falcata*. Even though *C. fimbriata* was present on several species in this study, it was more abundant in terms of occurrence as well as number of fruiting bodies per bark piece on *Pinus taeda* than on any other tree species used. This supports the notion of probable affinities of certain myxomycete species and certain tree species depending upon the locality.

As additional support suggesting certain species affinity between trees and slime mold species, a comparison is made between the occurrence of slime mold species on tree species in the Panola Mountain State Park study (Pendergrass, 1972) with the same tree species used in the current study. All of the tree species used in the Panola Mountain State Park study were used in this study except Quercus prinus and Carya glabra. This study, therefore, enables a comparison to be made between Cornus florida, Pinus taeda, Pinus echinata, Liriodendron tulipifera, and Quercus falcata, tree species common to both studies.

In the Panola Mountain study Cribraria violacea was predominant on Cornus florida. In this study the predominant myxomycete species occurring on Cornus florida bark were Licea operculata and L. erecta. Cribraria violacea never appeared on bark from the Cornus florida trees sampled in this study. On the other hand, Licea operculata and L. erecta never appeared on bark from the Cornus florida trees used in the Panola Mountain study.

Echinostelium minutum was the most ubiquitous myxomycete in this investigation as well as in the Panola Mountain study. It was the only species that appeared on bark from Cornus florida that was common to both studies. However, it was not the only species to occur on bark of C. florida from either study.

Seven myxomycete species representing 7 genera were common in both studies on bark from Liriodendron tulipifera. These slime molds were Arcyria cinerea, Clastoderma debaryanum (listed as Cribraria microcarpa in the Panola Mountain study), Comatricha lurida, Cribraria violacea, *Didymium squamulosum*, *Echinostelium minutum*, and *Licea operculata*.

Pinus taeda had 6 myxomycete species that were common to this study and the Panola Mountain study. They were *Arcyria cinerea*, *Comatricha elegans*, and *C. nigra*, *Cribraria minutissima*, *Echinostelium minutum*, and *Physarum viride*. *Arcyria cinerea*, *Clastoderma debaryanum*, *Comatricha fimbriata*, and *Echinostelium minutum* were the only slime mold species common to both studies on bark of *Quercus falcata*.

These data provide additional information on the question as to whether there exists an affinity between species of trees and species of corticolous myxomycetes. Information from this study, that of Ku (1969), as well as this author's study (Pendergrass, 1972) agree with Peterson's (1952) speculation that certain species of slime molds appear to be specific for certain tree species within a particular locality and may not be specific for the same trees in another locality. For example, *Cribraria minutissima* was found only on bark from *Pinus taeda* in the Panola Mountain study whereas in this study it appeared commonly on 13 tree species including *Pinus taeda*. It developed more abundantly, however, on *Pinus taeda* when compared with other tree species used in this study. Another example is the affinity that appeared to have existed between *Cribraria violacea* and *Cornus florida* in the Panola Mountain study whereas in this study, involving a different locality, *Cornus florida* bark yielded *Licea operculata* and *Licea erecta* in greater abundance, with *C. violacea* being absent.

When seasonal variations in myxomycete occurrence is considered, Ku (1969) reported the occurrence of some species of myxomycete on bark collections throughout the year. He also reported that a greater number of species and generally a greater abundance of fruiting bodies were found on bark samples collected during the spring season. Similar findings were reported by Peterson (1952), Ku reported that 62.5 percent of the bark samples that he collected were positive during the spring and 52.2 percent were positive during the summer. In the Panola Mountain study (Pendergrass, 1972), 91 percent of the bark pieces collected in the spring were positive and 89 percent in the summer. In this current two-year study only a very slight difference was noted between the percent of bark samples positive for myxomycetes when spring and summer collections are compared. During the summer seasons 75.1 percent of the bark pieces collected were positive and 72.5 percent of the bark pieces collected during the spring seasons were positive. When all of the studies are considered it is clear that bark collections in summer and spring seasons are more productive in myxomycete yield than they are during other seasons. Presumably the warm, moist weather that is characteristic of the spring and summer may provide conditions that are optimal for spore germination and plasmodial development.

Even though the cause for the difference in seasonal productivity of myxomycete occurrence on bark samples has not been determined, there are several possible factors that would influence development during the various seasons. According to Gray and Alexopoulos (1968), de Bary in 1884, Constaneau in 1906, Gilbert in 1929, and Smart in 1937, have shown that temperature influences the germination of myxomycete spores and consequently influences differences in myxomycete development during the different seasons. Other assumptions relative to seasonal variations in myxomycete occurrence includes the notion that species that appear during the winter in moist chamber culture may require alternate high and low temperatures or low temperatures alone as a prelude to the activation of spore germination, plasmodial formation and fruiting body development. Gilbert (1929), Smart (1937) and Klinge (1974), for instance, have reported that spores of certain myxomycete species require low or high temperature exposure before they will germinate. Smart has also shown that the optimum temperatures for spore germination of species that he tested were in the range of 22 - 30 C with most of the germination occurring at the high temperatures. He also noted that below 10 C or above 32 C, the rate of germination was slower and percentage of germination was greatly reduced. Smart did find that some spore germination did occur from 2 - 36 C. The relatively high temperature requirement for the activation of spore germination is probably one of the reasons why myxomycete productivity appears to be more abundant during the spring and summer months when bark samples are incubated under moist chamber conditions.

Even though some indication was found of variations in seasonal occurrence of myxomycetes in this study as well as in other similar studies (Ku, 1969; Pendergrass, 1972), there is some question as to whether the moist chamber method is a valid technique for determining seasonal variations. Peterson (1952), for instance, suggested that it is probable that by collecting bark samples and incubating them in moist chambers any pre-existing seasonal influence upon myxomycete development may be changed. Therefore, factors contributing to seasonal occurrence of a species of myxomycete would have to have exercised their influence prior to the collection of samples. It is assumed that wind-dispersed spores should be present at all times on tree bark. If this is the case, unless there are contributing factors related to seasons of the year, these spores should germinate and fruiting bodies should appear in moist chamber culture regardless of the time of the year the collection was made. Consequently, the same species of corticolous myxomycetes should occur throughout the year on all bark pieces unless the myxomycetes possess physiological mechanisms that are influenced by seasonal conditions.

Klinge (1974) suggests that other factors such as pH, position of the myxomycete on the substrate, light intensity, and moisture content of the substrata also play a role in myxomycete occurrence. She has shown that elemental content of the substrate appears not to be significant in influencing myxomycete occurrence.

In contrast to the findings in this study, Brooks (1967) suggests that bark removed from a tree and placed in a moist chamber is no longer subject to the environmental conditions characteristic of the tree habitat and that the species obtained in moist chamber cultures should be regarded as terrestrial invaders and not corticolous. He contends that proof of corticolous habit depends on collection of the myxomycete *in situ*.

Peterson (1952) has also suggested that bark of living trees may not be a natural substratum for myxomycete development. He drew this conclusion after completing his study on myxomycetes from bark of living trees. Peterson's conclusion was drawn because during his study he used the moist chamber method and postulated from his results that by collecting bark samples and incubating them in moist chamber cultures pre-existing influences upon myxomycete development may be changed and thus may inhibit or enhance myxomycete occurrence. Peterson and Brooks are in agreement on the matter of bark not being a natural substratum for myxomycete occurrence.

This study indicates that the same species that occur *in situ* may also occur in moist chamber cultures if conditions are favorable. To demonstrate this several culture techniques were used in order to ascertain differences in myxomycete developments under *in vivo* and *in vitro* conditions.

The slime mold species that appeared in moist chambers as well as *in situ* were *Arcyria cinerea*, *Comatricha elegans* and *Enerthenema papillatum*. *Echinostelium minutum* and *Comatricha elegans* even appeared in the polyethylene bags attached to trees. It appeared that the principal requirement lacking for slime mold development *in situ* was moisture and when it was provided fruiting subsequently occurred.

A further indication of the validity of the moist chamber technique is provided by the occurrence of all the myxomycete species reported *in situ* by Brooks (1967) and the ones found *in situ* in this study also in moist chamber cultures. Brooks reported the following genera as the most commonly occurring corticolous slime molds: *Licea*, *Macbrideola*, *Echinostelium*, and *Badhamia*, all of which are reported from moist chamber culture in this study. If, therefore, the same myxomycetes that occur in moist chamber cultures are also commonly found *in situ*, further support of the contention that bark is a natural substrate for myxomycetes is provided.

Additional data from this study strongly supports the contention that bark from living trees is a natural substratum for many species of myxomycetes for in this study it was found that some myxomycete species develop on bark of living trees as well as on forest floor debris. Other species develop only on bark of living trees or only on fallen debris. For example, Comatricha fimbriata, C. elegans, and Cribraria minutissima were common on bark from living trees but were uncommon on fallen debris. It is assumed that the wind disperses the spores equally on tree bark as well as on fallen debris, nevertheless, certain slime mold species occurred only on the bark of living trees and other species occurred only on fallen debris.

Even though plots of trees were selected in each locality where each tree stood only a few meters apart from the other, some slime mold species occurred on bark samples from all of the tree species that were productive, e.g., Echinostelium minutum, and some other species appeared only on a single bark sample from a single tree species, e.g., Macbrideola decapillata. The abundant occurrence of some myxomycete species consistently on bark samples, the limited occurrence of others, and the characteristic size and relatively simple structure of forms of the types predominantly found on bark samples from trees, represent further evidence pointing to living tree bark as a natural substratum.

Another investigator who has presented additional evidence in support of the natural occurrence of slime molds on bark of living trees is Keller (1972). He maintains, however, that truly "corticolous" forms are those that can be found in situ. Species that develop on bark in moist chamber culture are not considered by Keller to be truly corticolous.

Further evidence that some slime mold species will fruit in situ on bark of living trees has been provided by Frederick (Personal communication, 1972) when on one occasion Echinostelium minutum was observed on bark samples of Pinus taeda immediately after the samples were collected. Frederick had postulated that following an extended period of continuous rain and high atmospheric moisture fruiting bodies of some corticolous slime molds could probably be found in situ if bark pieces from living trees were collected and immediately examined. Keller (1972) has also informed me that he and a colleague, Dr. Henry Aldrich, of the University of Florida, were successful in finding myxomycete species in the field on intact tree bark.

In light of the above reports the data presented in this study support the findings in the Panola Mountain State Park study (Pendergrass, 1972). In this study, bark samples collected after a prolonged rainy spell produced myxomycete fruiting bodies within two or three days of incubation. As mentioned previously, in one instance, during the course of this study, following a rainy spell myxomycetes were observed in abundance on bark of Pinus taeda in situ. Based on the evidence cited, myxomycetes more than likely occur frequently on bark of living trees naturally. Such observations provides further evidence in support of the claim that bark from living trees represents a natural substratum for certain myxomycete species.

It is still not clear as to what characteristic features of bark of living trees causes it to be a favorable substratum for certain myxomycetes. There is some indication, however, that bark texture and bark surface character may play a role. It was reported by Ku (1969) that trees with smooth, thin, bark produce fewer myxomycetes when bark samples are placed in moist chambers. Ku surmised that this type of bark provided less protection and less moisture for spores and plasmodia than thicker textured bark. In this study the bark of Quercus phellos is relatively smooth with a few irregular cracks. Q. phellos has a dark, deeply furrowed bark but was unproductive throughout the study. It may be that Q. phellos bark was unproductive because filamentous fungi usually grew rapidly and covered the bark pieces. Even though it would appear that this should not inhibit slime mold development, especially since Echinostelium minutum and some other abundant slime mold species occur under almost any kind of conditions, slime molds did not appear on Q. phellos bark. It was noted, however, during the course of this study, that in species of oak, other than Q. alba, filamentous fungi tended to appear within three or four days of incubation. When this happened very few slime mold species developed later. Those species that did appear would usually be a Physarum species or Echinostelium minutum. It appears, therefore, that texture of bark may play a role in spore retention and the maintenance of high moisture levels. Furthermore, bark of this nature may have a greater amount of dead tissues on its surface. Such conditions may be conducive to myxomycete development and result in the maintenance of a distinctive myxomycete bionta.

CHAPTER VI

SUMMARY

During a twenty-four month period, beginning in the summer of 1973 and ending in the summer of 1975, studies were conducted on the occurrence of species of myxomycetes on bark of living trees, using primarily the moist chamber technique. The trees studied were growing in selected plots in five widely separated localities in the city of Atlanta. The localities used were (1) a wooded area in the Highpoint section located about 4 miles south of downtown Atlanta, (2) a wooded hillside in the Collier Heights section located about 7 miles west of downtown Atlanta, (3) a wooded ravine in the Beecher Circle section located approximately 6 miles southwest of downtown Atlanta, (4) Washington Park - a city park located about 2-1/2 miles west of downtown Atlanta, and (5) Piedmont Park, another city park located approximately 3 miles from downtown Atlanta in the northwest section of the city. In two of the localities, viz., Collier Heights and Beecher Circle, leaf litter in each plot was occasionally observed for myxomycete occurrence at the time bark samples were collected.

Modified _in vitro_ and _in vivo_ techniques were also employed during the study in an attempt to approach natural field conditions. These modifications included (1) attaching polyethylene bags to the trees from which bark samples inside the bag had been removed, (2) placing bark samples in petri plates that were left in the field at the base of trees from which they were taken, and (3) keeping undisturbed bark on tree trunks continuously moist by allowing water to slowly drip from polyethylene bags attached around the tree trunks. Trunks of some trees were occasionally studied in the field for the presence of myxomycetes.

One hundred and seventy-one trees, representing twelve genera, viz., _Acer_ (2 species), _Carya_ (2 species), _Cornus_, _Cedrus_, _Diospyros_, _Prunus_ _Liquidambar_, _Liriodendron_, _Ostrya_, _Pinus_ (2 species), _Quercus_ (6 species), and _Ulmus_ (2 species) were selected for this study. Forty-six species of myxomycetes have been obtained from the bark samples collected and the leaf litter observed. Single species of the genera _Calomyxa_, _Ceratiomyxa_, _Clastoderma_, _Dictydium_, _Diderma_, _Echinostelium_, _Enerthenema_, _Fuligo_, _Hemitrichia_, _Lamproderma_, _Lycogala_, and _Metatrichia_ have been identified. Two species of _Badhamia_, _Cribraria_, and _Perichaena_, 3 species of _Arcyria_, _Didymium_, and _Licea_, 4 species of _Macbrideola_ and _Stemonitis_, 5 species of _Comatricha_ and 6 species of _Physarum_, were the other myxomycetes found. The most ubiquitous species found in this study was _Echinostelium minutum_. This species appeared throughout the study on all the trees selected with the exception of _Acer saccharinum_, _A. negundo_, _Cedrus deodara_, and _Quercus phellos_. _Q. phellos_ was non-productive throughout the 2 years of the study.

Next to _E. minutum_, _Comatricha fimbriata_ was the most widespread in occurrence in terms of species of trees where they were found. _C. fimbriata_ was found on 15 tree species, two less than _Echinostelium minutum_. Some of the myxomycetes appear to have general affinities for certain tree species. _Macbrideola cornea_, for instance, has appeared only on bark of _Quercus alba_, and _M. decapillata_ appeared only on bark of _Quercus stellata_. Another myxomycete species, _Arcyria carnea_, also appeared only on bark of _Quercus alba_. Some of the myxomycete species that were found growing on various substrata on the forest floor were not found on bark from trees in those plots. For example, Ceratiomyxa fruticulosa, Dictydium cancellatum, Fuligo septica, Hemitrichia stipitata, Lycogala epidendrum, and Metatrichia vesparium were often found on fallen debris but never appeared on bark from living trees. There were some myxomycete species, however, that were found on both bark of living trees as well as on fallen debris. Arcyria cinerea, A. nutans, Physarum cinereum, P. nutans, and P. viride, Stemonitis axifera and S. fusca were the species found that were common to leaf litter and living tree bark. Arcyria cinerea, Comatricha elegans and Enerthenema papillatum were the only 3 species of slime molds that were found growing naturally on the bark of trees.

Bark of living trees appears to be a natural substratum for certain myxomycete species. This contention is supported by the affinities noted to have occurred between some species of trees and species of myxomycetes with variations depending upon the locality. Furthermore some of the species found are only known from living tree bark.

Some differences were noted relative to seasonal distribution. These differences were not marked, however, and the reasons the differences occurred are not clear.

Several of the species of myxomycetes found represent new records for the state of Georgia. The species previously unreported are Calomyxa metallica, Clastoderma debaryanum, Badhamia nitens, Badhamia obovata, Licea erecta, Macbrideola cornea, M. decapillata, M. martinii and M. synsporos, Perichaena minor, Physarum crateriforme, P. decipiens and P. leucophaeum.

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